TELE-TECH

Formerly the TELE-communications TECH-nical Section of

ELECTRONIC INDUSTRIES

APRIL, 1947

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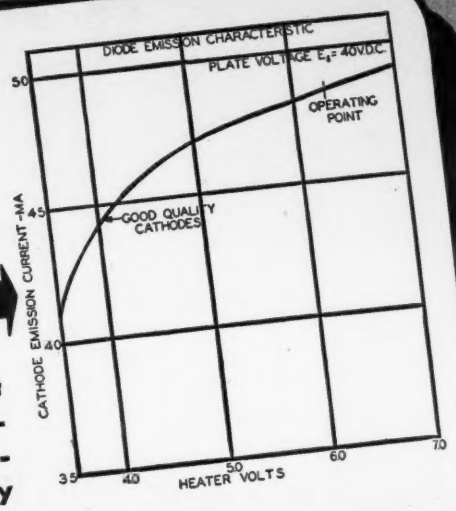

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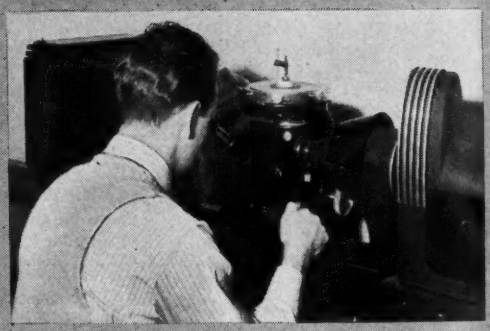

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O. H. CALDWELL, EDITOR ★ M. CLEMENTS, PUBLISHER ★ 480 LEXINGTON AVE., NEW YORK (17), N. Y.

More Power for FM

More station power is urged by metropolitan FM broadcasters as city set owners complain of interference from passing automobiles—convincing evidence that radiation from high antennas cannot penetrate skyscraper canyons, despite good coverage in suburban areas. Allowing only frugal grants of power to preclude future station interference, the FCC continues to solve tomorrow's problem today, ignoring today's problem altogether. Now under attack by many FM licensees is the 500 ft.-rule curbing powers for antennas of higher elevation. Receivers virtually beneath these "ideal" antennas and within the primary coverage area, just don't get enough microvolts.

Air Navigation

While in almost every direction in which the use of electronics has been initiated vast fields of endeavor appear to be opening up, one of the greatest of these is the field—in fact the blue sky of aviation. The amount of electronic equipment which is going to be needed to supply this growing industry is great and the sums involved are large. Furthermore it appears that this will be a quality market.

Pocket Magnetic Recorder

Wire and magnetic paper-tape recording are far from new, but are rapidly emerging from the lab into the commercial field.

During the war OSRD had Brush Laboratories, Cleveland, develop a *pocket recorder,* the size of a home movie camera. It would go in an overcoat pocket. With it a 30-minute conversation could be recorded with fidelity up to 3500 cycles. Big disadvantage was winding spring motor every one-half minute. However, think how handy small recorder would be for, say a reporter to have in his pocket while interviewing a prominent man. Or for the busy executive to take along on week end trips, to catch up on his memos and correspondence.

The Mobile Telegraph Office

As the telegraph engineers enlist radio to supplement and supplant their wire systems, they find new flexibility of service.

Take the case of the roving telegraph office in a delivery auto, now operating experimentally in the suburbs of Baltimore by FCC authorization. With the automobile assigned to a certain area, messages for that region are dispatched by radio directly to the car. On receipt, the operator types down the message on the familiar yellow blank, then cranks up the car engine and drives to the address given, to deliver the message. She can even wait for a reply, and transmit it immediately, from the curb in front of the sender's home. Office rent and delivery-boy wages are eliminated, and service is speeded up. Next!

Surplus Surpluses

Although the manner of disposal of surplus radio equipment may not be the best, few in the industry seem to be much alarmed about the matter. The question more often raised is why such an awful lot (and we do mean awful) of the stuff was ever designed in the first place, let alone built.

Manufacturers of an item were often in the dark as to what it was to be used for, and it was considered an offense to the secrecy act for them to try to find out. Now that it is all over and the assigners and builders have a chance to check up with some of the men who were supposedly the users—they can only just wonder! It is not strange that so much of the nameless gazinkas are bringing only a few cents on the dollar.

NEXT MONTH — FM ENGINEERING ISSUE

With hundreds of new frequency-modulation broadcast stations being erected and going on the air, while millions of combination AM-FM home receivers are scheduled to be designed and manufactured during coming months, engineering interest in FM is at an all-time peak.

The May issue of *Tele-Tech* appropriately will cover a number of topics of timely interest to readers concerned with FM problems. This issue also will be distributed at the important Parts Show in Chicago, May 13 to 16.

The Acoustical Design of FM

Obtaining brilliant tonal values throughout the audible range by improving overall frequency response and the distribution of sound

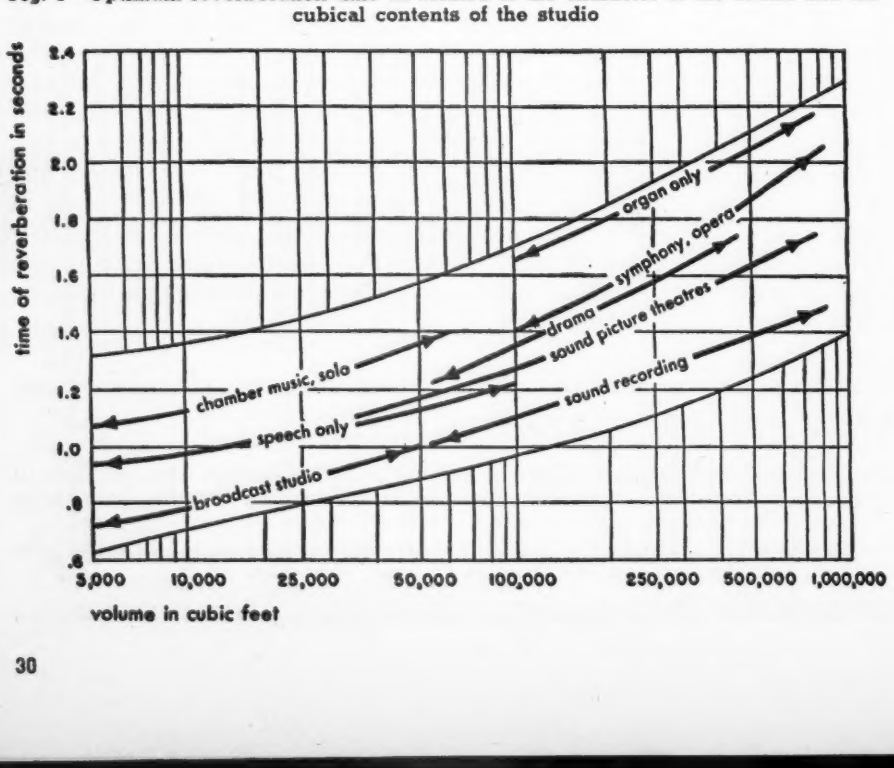
• FM broadcasters are paying more attention to the acoustical design of broadcast studios in an effort to take full advantage of the inherent high fidelity of FM. The objective is to attain brilliant tonal values throughout the audible range by improving overall frequency response and the distribution of sound throughout the studio. It is well known that the frequency response of a room is dependent upon the reverberation times at various frequencies throughout the audible range. The relative loudness of tone at the different pitches will depend upon the integration of the respective reverberation times over the audio spectrum range. These will vary due to resonances, atmospheric attenuation, absorption, etc.

The acoustical problem of broadcast studios falls generally into two categories. The first is *sound isolation* and the second is the treatment for *acoustical excellence* within the confined space. The signal-to-noise ratio can be controlled by adequate sound installation of the studio by sealing the chamber and virtually suspending it so that no sound can be transmitted through the walls, ceiling and floor.

> *"NO specific requirements are made relative to the designated acoustical treatment of [FM] studios. However, the design of studios, particularly the main studio, shall be compatible with the required performance characteristics of FM broadcast stations."*—FCC

After some interesting experiments on the subject of human hearing, Dr. Harvey Fletcher of the Bell Telephone Laboratories stated his results in part as follows: "Substantially complete fidelity in the transmission of orchestral music is obtained by the use of a system having a volume range of 65 decibels, and frequency range of from 60 to 8,000 cycles per sec. Substantially complete fidelity for the transmission of speech is obtained by a system having a frequency range of 100 to 7,000 cycles per sec., and a volume range of 40 db."

Fig. 1—Optimum reverberation time as related to the character of the sound and the cubical contents of the studio



Background Noise

Orchestral music varies in level from about 30 to 105 db; conversational speech varies from about 30 to 80 db, averaging about 70 db. The background noise of a studio for FM broadcasting should be about 25 db, and never higher than 30 db which is the lower audible limit of speech and musical sound. These acoustical levels are based on a reference level of 10^{-16} watt per square centimeter of sound energy and are values indicated by a properly calibrated sound level meter. A studio noise level of less than 25 db is desirable.

Undesirable resonances within the studio may be effectively reduced by non-parallelism between opposing surfaces to eliminate standing waves. Since the early days of broadcasting, studios have progressed from flat surfaces and dead characteristics to studios designed for greater liveness through the use of *splayed* or *convex* surfaces.

A typical example of a studio

Studios

By EDWARD J. CONTENT
Acoustical Consultant
Stamford, Conn.

General view of WOR studio No. 16, constructed in accordance with design considerations outlined in the text

which would ideally serve an FM broadcaster as a main studio is one of a group of three designed by the author for the Mutual Broadcasting System at WOR in New York. The studio is well proportioned since the dimensions progress according to the cube-root-of-two rule. By this rule the dimensions progress in multiples of one-third of an octave. This particular studio is 14 ft. high, 22 ft. wide and 35 ft. long having a volume of 10,800 cu. ft. which is large enough to accommodate a fifteen or eighteen piece orchestra.

The location of these studios is near Times Square, one of the noisiest sections in New York. To accomplish adequate sound isolation, the floors were made completely "floating" by "H" section metal sleeper bars mounted on springs on top of the existing concrete floors. Void spaces were filled with loose rock wool to prevent resonances of these random columns of air. The entire floor assembly was then covered with a 15 lb. weight felt paper which was overlapped and sealed to form a tight membrane. A welded wire reinforcement forming a net was laid over the felt paper, and a concrete floor 2½ in. thick was poured to provide further sound isolation. This floor was isolated from the walls by filling a small space around the perimeter with felt stripping.

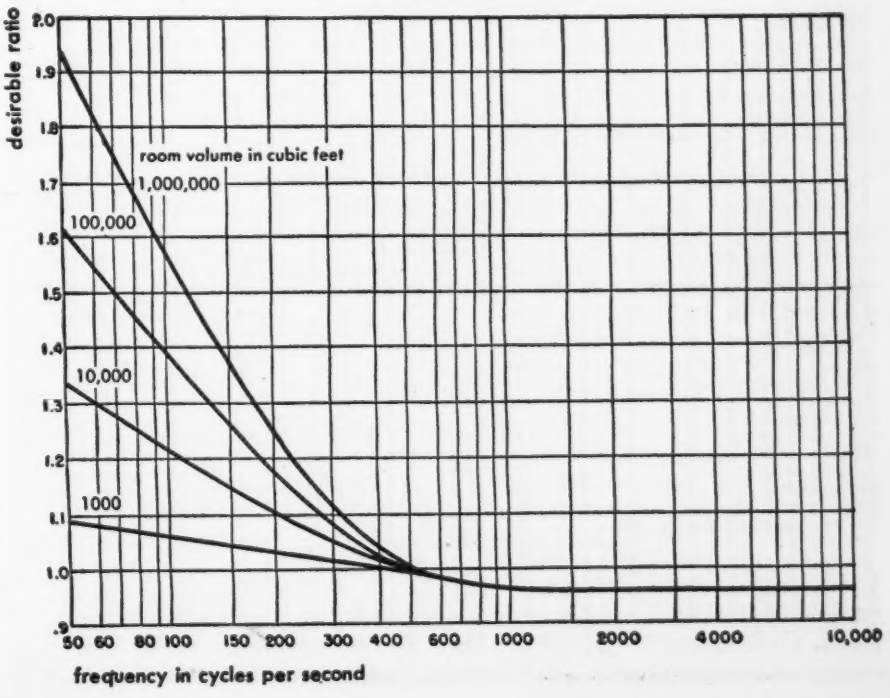
Each main side wall of the studio consists of two 4 in. masonry walls separated by a 1 in. layer of hair felt. This felt layer effectively isolates the front wall from the back one and prevents mortar from dropping between the double-wall cinder block construction and short circuiting the isolation effect. The inner walls of the studio were suspended from these masonry walls by metal and felt wall isolators.

The base of the inside walls also is mounted on springs and supported by the original concrete floor. These inside walls consist of 1 in. steel channels which are fastened to the wall isolators. Metal lath is mounted on these channels and plaster is applied to form the finish. The plaster wall is recessed to accommodate the acoustical absorbent wherever it is specified so that the finished surface of the treatment may be flush with the untreated surfaces. This results in an interior of finished appearance in contrast with the appliquéd surface which results when the acoustical treatment is applied after the studio walls have been built.

Two layers of 1 in. metal channels suspended by metal-felt isolators form a shockproof chain suspension between the concrete super-structure and the finished studio ceiling. Between the lower channel layer and the studio ceiling is a 2 in. rock-wool blanket to further aid sound isolation.

All air conditioning ducts were lined with ½ in. Airacoustic sheets to reduce direct noise transmission

Fig. 2—Desirable reverberation time vs. frequency for various structures and auditoriums as compiled by Western Electric Co. The desirable reverberation time for any frequency between 60 and 8000 cycles may be found by multiplying the reverberation time at 512 cycles by the number in the vertical scale corresponding to the frequency chosen



Close-up of one end of the WOR No. 16 studio, showing detail of one of the acoustically treated wall surfaces

from one studio to another and to suppress fan noise and air hiss. Where the ducts enter the suspended studio chamber, they are broken and fitted with canvas sleeves to prevent any direct sound transmission. Ducts of cross-sectional area larger than normal were used to reduce the air velocity, and thus air rush.

The overall ambient noise level in the studios is between 26 and 27 db. The average noise level in residences with the radio turned off is 43 db according to Seacord. These studios therefore meet much more stringent requirements than is necessary since the reproduction of the original studio program in the home is made with a considerably higher background noise level.

The reverberation time, the principal acoustical dimension of broadcast studios, is the time in seconds required for sound to diminish 60 db from its original value. It can be calculated from a basic formula developed by Professor Carl Eyring.

$$t = \frac{0.049V}{-S \log_e(1-\alpha_{av})}$$ where;

t = time in seconds for 60 db decay of sound

V = room volume in cubic feet

S = room surface area in square feet

α_{av} = average absorption coefficient

If the volume is measured in cubic meters and the area in square meters, the formula is:

$$t = \frac{0.161V}{-S \log_e(1-\alpha_{av})}$$

Table I—Acoustical coefficients of materials and persons†

†*From "Architectural Acoustics", John Wiley & Sons, New York*

description	sound absorption coefficients cycles per second 128	256	512	1024	2048	4096	authority
Brick wall unpainted	0.024	0.025	0.031	0.042	0.049	0.07	W. C. Sabine
Brick wall painted	0.012	0.013	0.017	0.02	0.023	0.025	W. C. Sabine
Plaster + finish coat Wood lath—wood studs	0.020	0.022	0.032	0.039	0.039	0.028	P. E. Sabine
Plaster + finish coat on metal lath	0.038	0.049	0.060	0.085	0.043	0.056	V. O. Knudsen
Poured concrete unpainted	0.010	0.012	0.016	0.019	0.023	0.035	V. O. Knudsen
Poured concrete painted and varnished	0.009	0.011	0.014	0.016	0.017	0.018	V. O. Knudsen
Carpet, pile on concrete	0.09	0.08	0.21	0.26	0.27	0.37	Building Research Station
Carpet, pile on 3/8" felt	0.11	0.14	0.37	0.43	0.27	0.25	Building Research Station
Draperies, velour, 18 oz per sq yd in contact with wall	0.05	0.12	0.35	0.45	0.38	0.36	P. E. Sabine
Ozite 3/8"	0.051	0.12	0.17	0.33	0.45	0.47	P. E. Sabine
Rug, axminster	0.11	0.14	0.20	0.33	0.52	0.82	Wente and Bedell
Audience, seated per sq ft of area	0.72	0.89	0.95	0.99	1.00	1.00	W. C. Sabine
Each person, seated	1.4	2.25	3.8	5.4	6.6	—	Bureau of Standards, averages of 4 tests
Each person, seated	—	—	—	—	—	7.0	Estimated
Glass surfaces	0.05	0.04	0.03	0.025	0.022	0.02	Estimated

Table II—Coefficients of materials used for acoustical correction*

**Noise reduction coefficient, from Acoustic Materials Assn.*

material	cycles per second 128	256	512	1024	2048	4096	noise-red coef *	manufactured by
Corkoustic—B4	0.08	0.13	0.51	0.75	0.47	0.46	0.45	Armstrong Cork Co.
Corkoustic—B6	0.15	0.28	0.82	0.60	0.58	0.38	0.55	Armstrong Cork Co.
Cushiontone A-3	0.17	0.58	0.70	0.90	0.76	0.71	0.75	Armstrong Cork Co.
Koustex	0.10	0.24	0.64	0.92	0.77	0.75	0.65	David E. Kennedy, Inc.
Sanacoustic (metal) tiles	0.25	0.56	0.99	0.99	0.91	0.82	0.85	Johns-Manville Sales Corp.
Permacoustic tiles 3/4"	0.19	0.34	0.74	0.76	0.75	0.74	0.65	Johns-Manville Sales Corp.
Low-frequency element	0.66	0.60	0.50	0.50	0.35	0.20	0.50	Johns-Manville Sales Corp.
Triple-tuned element	0.66	0.61	0.80	0.74	0.79	0.75	0.75	Johns-Manville Sales Corp.
High-frequency element	0.20	0.46	0.55	0.66	0.79	0.75	0.60	Johns-Manville Sales Corp.
Absorbatone A	0.15	0.28	0.82	0.99	0.87	0.98	0.75	Luse Stevenson Co.
Acoustex 60R	0.14	0.28	0.81	0.94	0.83	0.80	0.70	National Gypsum Co.
Econacoustic 1"	0.25	0.40	0.78	0.76	0.79	0.68	0.70	National Gypsum Co.
Fiberglas acoustical tiletype TW-PF 9D	0.22	0.46	0.97	0.90	0.68	0.52	0.75	Owens-Corning Fiberglas Corp.
Acoustone D 11/16"	0.13	0.26	0.79	0.88	0.76	0.74	0.65	U. S. Gypsum Company
Acoustone F 13/16"	0.16	0.33	0.85	0.89	0.80	0.75	0.70	U. S. Gypsum Company
Acousti-celotex type C-6 1 1/4"	0.30	0.56	0.94	0.96	0.69	0.56	0.80	The Celotex Corp.
Absorbex type A 1"	0.41	0.71	0.96	0.88	0.85	0.96	0.85	The Celotex Corp.
Acousteel B metal facing 1 5/8"	0.29	0.57	0.98	0.99	0.85	0.57	0.85	The Celotex Corp.

Studio Calculations

The total area in the WOR studio has the following distribution:

Surface	Area (sq. ft.)	% of Total
Floor and ceiling	**1540**	**49**
Side walls	**980**	**31**
End walls	**616**	**20**
Total Area (S)	**3136**	**100**

To distribute the acoustical treatment uniformly in the three planes, it is necessary to install 49% on the ceiling, 31% on the side walls and 20% on the end walls. By distributing the treatment in this manner the tendency is to equalize reverberation time between any two walls. For a given confined space, the ratio of V/S (volume to surface) is a constant. If we let f equal 0.049 V/S, and

$-\log_e(1-\alpha_{av}) = Q$, then $t = \frac{f}{Q}$

For the studio under discussion f is equal to $\frac{0.049(10{,}800)}{3136}$ or 0.169

From the known factors we can then develop a table of computations.

Atmospheric attenuation at higher frequencies is greater than

at lower frequencies, and a more accurate reverberation time is given by the following formula developed by Professor V. O. Knudsen:

$$t = \frac{0.049V}{-S \log_e(1-\alpha_{av}) + 4mV}$$

where m is the attenuation constant per foot of propagation path and V, the cubic volume. For a relative humidity between 40 and 50%, the value of m from Fig. 4 for 4,096 cycles is 0.002. Substituting values in the formula:

$$t = \frac{(0.049)\ (10{,}800)}{[(3136)\ (0.214)\ ] + [\ (4)\ (0.002)\ (10{,}800)\ ]}$$

$$= 0.70 \text{ seconds}$$

This checks with the optimum reverberation time desired (Item 2), and is a better value than 0.74 sec. (Item 18) which does not allow for atmospheric attenuation.

Non-Parallelisms

When a transmission line is not terminated in its characteristic impedance, electric energy is reflected back in such a way that standing waves appear on the line. Similarly, standing sound waves exist in a confined space when the sound wave is reflected from the walls. If all of the contour surfaces of the room were 100% sound absorbent, the absence of reflected sound energy would cause an orchestra to sound as though it were playing outdoors; it would lack brilliance. The objective is to obtain brilliance in a studio without allowing complex resonant patterns to be set up. Angled panels or polycylindrical surfaces have been in use for some time in order to obtain sound diffusion for liveness, without objectionable room resonances. Since main objective is diffusion, either angled surfaces or convex surfaces may be used, although the former are less costly. Some engineers believe that cylindrical construction provides better diffusive properties. The WOR studio under discussion uses both angled and convex surfaces.

These surfaces should be apportioned so that dispersions are equal in the three dimensional planes. As a further step to reduce wave patterns, it is well to angle the walls so that sound is dispersed in different planes. For example, if the south wall of the studio disperses sound eastward and westward, the north wall should disperse upward and downward. If the east wall disperses northward and southward, the west wall should also disperse upward and downward. The splayed ceiling should disperse northward and southward as well as eastward and westward. These conditions obtain in the design of WOR studio 16.

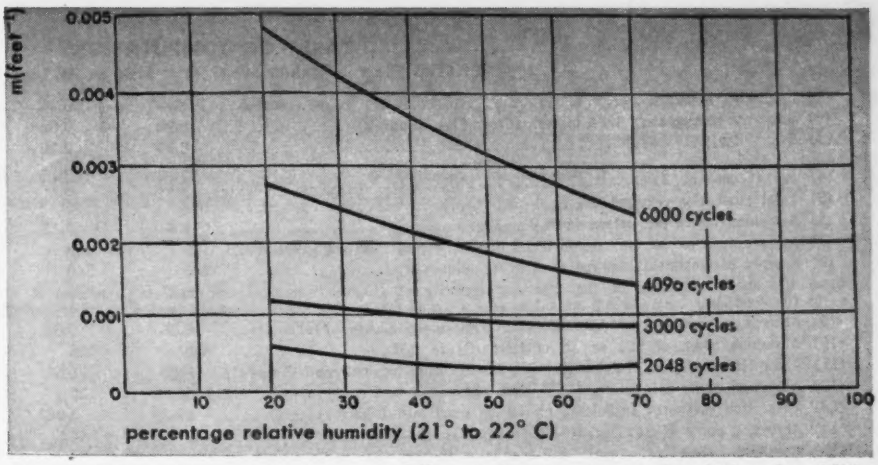


Fig. 4—Attenuation constant m at different frequencies and relative humidities

Conclusions

Those who recall the days of early broadcasting studios when walls were draped and the ceiling was lined with velvet or monk's cloth, recognize that studio acoustics have come a long way since then. Considerably more is known about the art and greater advances have been made in recent years to provide programs which can be described as "pleasant listening."

The real down-to-earth test of a newly designed studio is: how does it sound? Precise engineering calculations notwithstanding, if the studio does not sound right, it isn't properly treated.

Despite the encouraging advances

Fig. 3—Plot of the average absorption coefficient against $Q = -\log_e(1-\alpha_{av})$

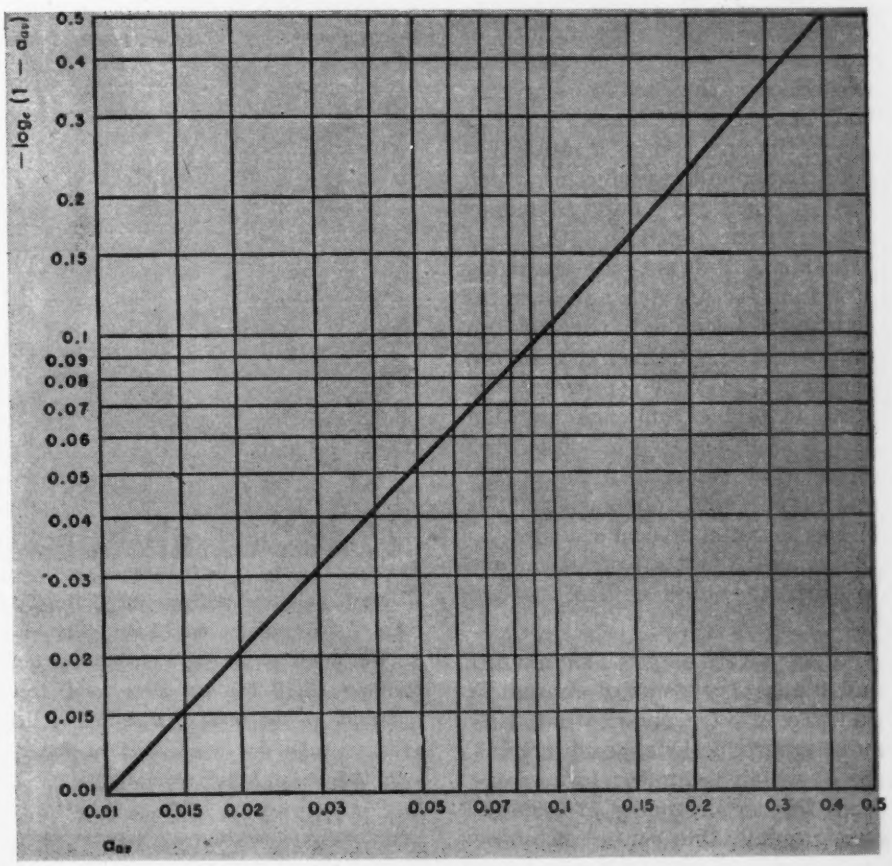


TABLE OF COMPUTATIONS

CONSTANTS: V = 10,800 cu. ft., S = 3136 sq. ft., and f = 0.169

(1) Frequency in cps	128	256	512	1024	2048	4096
(2) Optimum reverberation time in sec. (From Figs. 1 and 2)	0.90	0.82	0.75	0.70	0.70	0.70
(3) $Q = -\log_e (1 - \alpha_{av}) = f/t$	0.19	0.20	0.23	0.24	0.24	0.24
(4) α_{av} (From Fig. 3)	0.17	0.19	0.20	0.21	0.21	0.21
(5) Total absorption required ($\alpha_{av}S$) in A.U.*	534	580	633	665	665	655
(6) Absorbing power per person in A.U.	1.4	2.25	3.8	5.4	6.6	7.0
(7) Average audience for this studio is 18 persons; human absorbing power in A.U.	25	40	68	97	112	126
(8) Amount of treatment required in A.U. (5 minus 7)	505	540	565	568	553	539
From the above, estimates of the type and quantity of absorbent material are made by a process of trial and error until a set of values is found that seems to fit the conditions best. Below are values of such empirical computations. Bear in mind that other materials of different areas may accomplish the same results.						
(9) Absorption coefficient of Johns-Manville triple-tuned element (Table II)	0.66	0.61	0.80	0.74	0.79	0.75
(10) Absorbing power of 500 sq. ft. of Item (9) in A.U.	330	305	400	370	395	375
(11) Absorption coefficient of Johns-Manville low-frequency tuned element (Table II)	0.66	0.60	0.50	0.50	0.35	0.20
(12) Absorbing power of 200 sq. ft. of Item (11) in A.U.	132	120	100	100	70	40
(13) Absorption coefficient of finished plaster on wood lath (Table I)	0.020	0.022	0.032	0.039	0.039	0.028
(14) Absorbing power of 2436 sq. ft. untreated areas (S—[500+200]) A.U.	49	54	78	95	95	68
(15) Resultant absorbing power of studio with an 18 piece orchestra (7+10+12+14). Compare with (5)	536	520	646	662	637	619
When the studio is treated as above the reverberation times can now be computed from the formula $t = f/Q$ where Q is found from Fig. 3 when α_{av} is known.						
(16) α_{av} = total A.U./S	0.17	0.16	0.20	0.21	0.20	0.20
(17) $Q = -\log_e (1 - \alpha_{av})$. From Fig. 3	0.19	0.18	0.23	0.24	0.23	0.23
(18) $t = f/Q$ in seconds. (Compare with Item 2)	0.89	0.94	0.74	0.75	0.74	0.74

*Absorption Units. 1 A.U. is equivalent to the absorbing power of 1 sq. ft. of open window.

Item (1) is the pitch progressing in full octave steps from 128 to 4096 vibrations per second.

Item (2) is the optimum reverberation time taken from Figs. 1 and 2.

Item (3) is the Q or $-\log_e (1 - \alpha_{av})$ determined by the relation $Q = f/t$.

Item (4) is α_{av}, the average absorption coefficient found in Fig. 2 when Q or $-\log_e (1 - \alpha_{av})$ is known.

Item (5) is the total number of absorption units required and is found by multiplying the total area (8) by the average absorption coefficient α_{av}.

Items (6) and (7) list the absorbing power of a typical size orchestra for this studio (18 persons).

Item (8) is the approximate amount of treatment required in terms of absorption units and is a basis for judging the amount and kind of treatment necessary.

Items (9) and (11) are absorption coefficients of two types of acoustical treatments, and Items (10) and (12) show the total absorbing power for 500 and 200 square feet of these treatments respectively. These areas are estimated from previous experience with similar studios. If they are far out of line, the computations will show it, and a new set of values must be tried.

Items (13) and (14) show the absorption coefficient and the total absorbing power of untreated areas (total room area S minus treated areas).

Item (15) lists the total studio absorbing power and includes a summation of treated areas, untreated areas, orchestra size, etc.

Items (16), (17) and (18) are the results of computations using the calculated total absorption (Item 15). Compare the resultant reverberation times, Item (18), with the rererberation times we set out to obtain, Item (2). Note that reasonable correlation exists between the two sets, except at 256 cycles per sec. These values can be improved by the trial and error process until satisfactory results are obtained.

in recent years, there is still a vast frontier to be pioneered. One avenue of approach is a study of the psychology of the sense of hearing. What is the nature of the reproduction of frequencies throughout the audio spectrum that impresses the human mind as the optimum? Some idealists believe that sound reproduction which has a perfectly flat frequency characteristic *must* be the best listening. However, the Academy of Motion Picture Arts and Sciences conducted tests in a theatre and found that the frequency response characteristic which provides the most favorable audience reaction droops approximately 26 db at 8000 cycles when referred to the middle and lower audio frequencies. This is corroborated to some extent by the general tendency of set owners to turn the tone control toward bass.

Finally a word about the monaural and binaural systems of reproduction. Tests have shown that binaural reproductions, each channel of which is limited to a maximum freqency response of 5000 cycles, provides pleasanter listening than a monaural system capable of reproducing frequencies up to 15,000 cycles per sec.

Binaural reproduction, of course, is not new. At the present time, the difficulties to be overcome far outweigh the advantages to be gained. However, in a field of science that advances as rapidly as radio, new technics may be developed that may overcome these difficulties overnight.

Binaural reproduction is a step toward transporting the listener vicariously from his home to the concert hall. A system of reproduction which will accomplish this, whether it be binaural or some system not yet known, naturally is desirable. This is but one of many problems in the acoustical field that must be solved if the average listener is to hear a program with the same naturalness he would were he at the program's origin.

ATOMIC FISSION

Using a pellet of radium-beryllium, Dr. John R. Dunning, world-authority on nuclear physics, draws a portrait of the splitting of U-235 by slow and fast neutrons on the face of a 20-inch cathode ray tube, for a meeting of American Industrial X-Ray Society.

REFERENCES

Fletcher, Harvey, Hearing, the Determining Factor for High Fidelity Transmission." *Proc. IRE.*, Vol. 30, pp. 266-277, June 1942.

Seacord, D. F., "Room Noise of Telephone Subscriber Locations," *Jour. Acous. Soc. Amer.* Vol. 12, pp. 183-187, July, 1940.

"Reference Data for Radio Engineers," Second Edition, Federal Telephone and Radio Corp.

Microwave Spectrum Analyzers

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Instrument developed for use at 9,300 mc provides visual information on operation of pulsed oscillators in bandwidth of 40 kc

• With the advent of pulsed oscillators for radar and other applications, the need for an instrument to show the various frequency components of the oscillator output became evident. In the case of a continuous wave oscillator, the energy is confined to one frequency which can be measured with a suitable wavemeter. In the conventional sine wave amplitude modulation of this CW oscillator, a carrier and two sidebands centered about the carrier result, the frequencies of which can also be measured by conventional methods. The carrier and sideband amplitudes when plotted as a function of frequency are referred to as a spectrum.

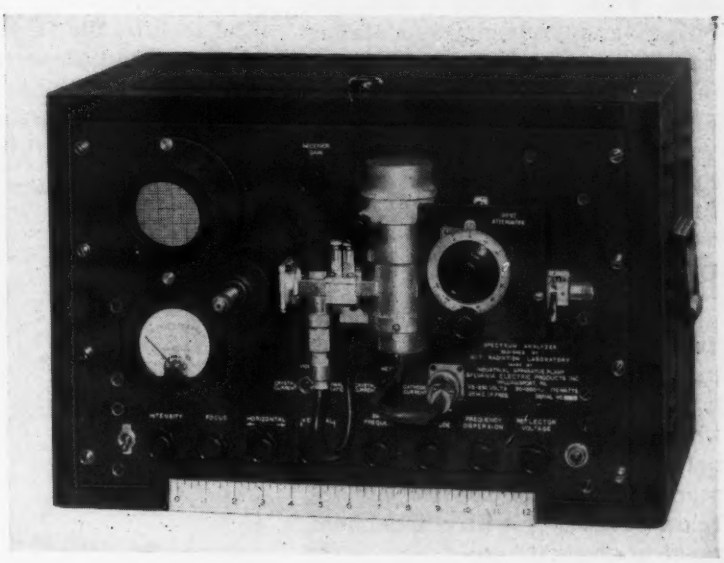


Fig. 1 — General appearance of spectrum analyzer for 9,300 mc in which the local oscillator is a tunable velocity modulated klystron of the reflex type

With pulsed oscillators, however, where a series of rectangular pulses are used to turn the oscillator on and off, the output occurs in short bursts of oscillation. In this case, the output consists of energy at many different frequencies. No simple method of determining the amplitude and frequency of these various components was available.

Early in the war, the development of a spectrum analyzer for use in the 3,000 mc region was undertaken by the Radiation Laboratory, Massachusetts Institute of Technology. The same organization also developed a unit for use in the 9,300 mc region. Both of these units were placed in production by the Industrial Apparatus Plant of the Sylvania Electric Products Inc. The resulting instrument, the higher frequency model of which is shown in Fig. 1, presents the information on the screen of a cathode ray tube.

The theoretical voltage spectrum of a pulsed oscillator may be obtained by the use of Fourier analysis. Fig. 2A shows the distribution of energy among the different frequencies for the case of an oscillator pulsed by a perfectly rectangular pulse of duration d and repetition rate fr. The spectrum analyzer displays this energy distribution on the screen of a cathode ray tube in a pattern resembling Fig. 2B. Although the individual lines appearing on the screen are not the individual sidebands, the shape of the envelope of the pattern appearing there closely resembles the theoretical spectrum, and thus offers a method of obtaining considerable information about the operation of the pulsed oscillator.

Essentially, the spectrum analyzer is a sharply tuned superheterodyne receiver with its frequency of reception made to sweep across the frequency spectrum to be analyzed at a rate that is slow compared to the pulse repetition rate of the oscillator being studied. At a given instant the receiver is tuned to accept a narrow part of the spectrum. The video output is then proportional to the power in the spectrum at that frequency.

While the oscillator under observation is pulsed on and off, the local oscillator of the receiver is progressively changing frequency, so that successive pulses find it tuned to slightly different portions of the spectrum. If, for example, the pulse recurrence rate is 1,000 times per second and the receiver's oscillator is swept at a rate of 20 cycles per second, there will be 50

lines displayed on the cathode ray screen. Each one of these lines will be proportional to the power in the spectrum at one of 50 frequencies, which differ in frequency from each other by an amount depending on the range through which the receiver's local oscillator is swept.

In actual practice the pulses applied to pulsed oscillators do not have a perfectly rectangular shape; they may exhibit tops with appreciable positive or negative slopes, and the rising and falling edges may be delayed to a noticeable extent. Such irregularities become evident in the output of pulsed oscillators as frequency modulation in addition to amplitude modulation. Pulsed oscillators with amplitude and frequency modulation have characteristic spectra differing markedly from that shown in Fig. 2. Some commonly encountered spectra displaying raised sidelobes caused by irregular pulse shapes are shown in Fig. 3.

RF and Mixer

As is shown in Fig. 4, the block diagram of an analyzer operating in the 9,300 mc region, the rf signal is coupled through an attenuator which controls the amount of signal fed to the mixer. This attenuator is a loop-coupled waveguide-below-cutoff type with a maximum range of about 100 db.

The local oscillator is a velocity-modulated klystron of the reflex type. It is frequency modulated by a sawtooth generator, the output of which is simultaneously applied to the horizontal deflection plates of the cathode ray tube. One may vary the amount of the resultant frequency swing to obtain varying dispersion of the spectrum up to a maximum of one mc/inch. A probe from the local oscillator projects into the waveguide, coupling power to the crystal mixer. Two tuning screws are placed between the crystal mixer and the coupling probe to insure that the proper impedance is presented to the local oscillator.

A reaction-type frequency meter is also attached to the waveguide structure through which the local oscillator power is fed to the mixer. When tuned to a certain frequency, the meter sharply reduces the energy, at that frequency, which reaches the mixer crystal from the local oscillator.

Since the sensitivity of the analyzer is high, and for many applications oscillators with considerable power output are located nearby, extreme care is required to provide adequate rf shielding. To make operation at the maximum sensitivity feasible, the local oscillator and crystal have shielding greater than the sum of the losses in the plumbing and the losses in the attenuator at the maximum setting; that is, greater than 100 db.

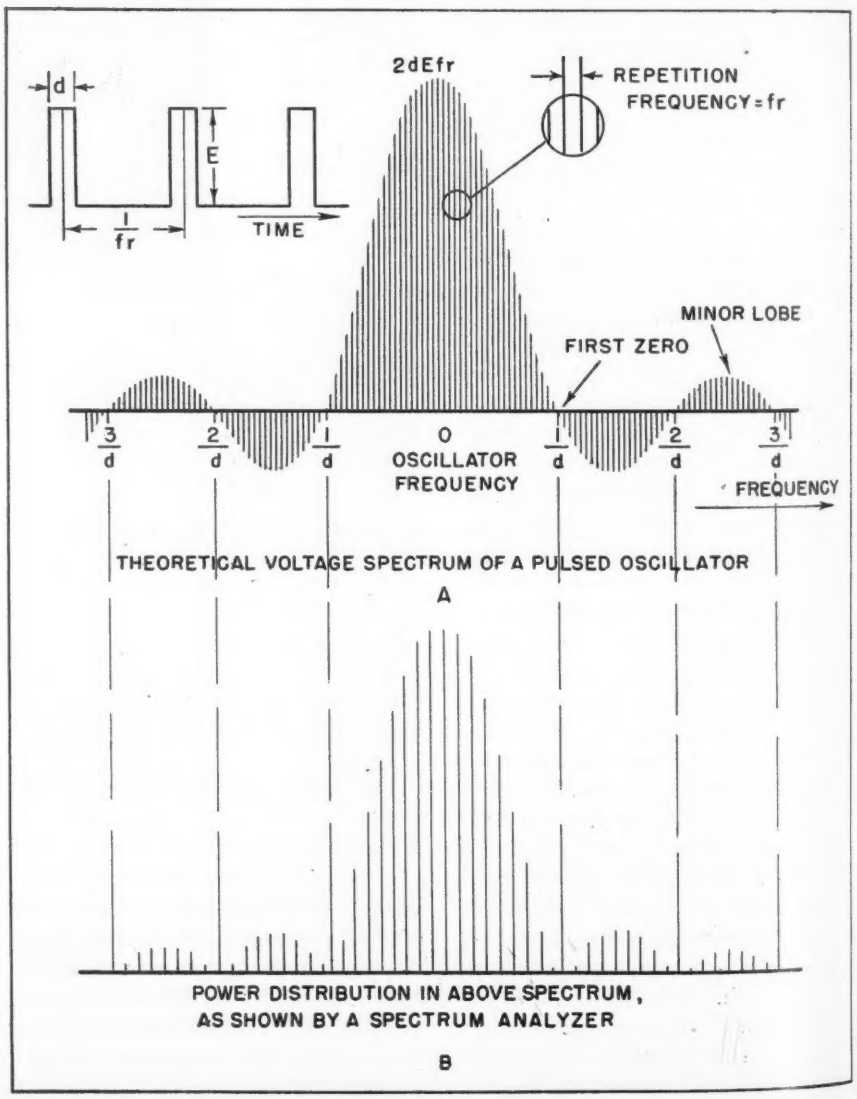
To secure this protection at microwave frequencies, the local oscillator is located in a tight metal enclosure with power leads entering through powdered iron chokes. The lead to the IF amplifier from the crystal also contains powdered iron chokes to prevent spurious signals from entering at this point. The cable used for this connection and all connecting cables are of double-shielded construction with shielded coaxial connectors.

IF and Detector

The choice of frequency for the IF amplifier is determined to a large extent by the width of the spectrum which it is desired to observe.

The output of an oscillator pulsed by a rectangular wave which rises to a maximum in a fraction of a microsecond will have considerable energy at frequencies several mc from its center frequency. Accordingly, it is desirable to be able to sweep the receiver local oscillator through a range of 20 mc or more

Fig. 2—Spectrum of pulsed oscillator showing at A theoretical spectrum for a perfect rectangular pulse, and at B, corresponding screen pattern, the actual spectrum being the envelope of the pattern of lines; lines are a result of the operation of the analyzer and are not a part of the spectrum itself



maximum. Since there is no preselection in the rf stage, this dictates an IF of 15 mc or higher to prevent other images of the observed spectrum from appearing on the cathode ray tube screen. The amplifier used in the analyzers described in this paper is tuned to 20 mc.

Since it is desirable to have a very narrow bandwidth for displaying a spectrum properly, the bandwidth is about 40 kc. The selectivity is obtained in four IF stages using single-tuned transformers. The two stages in which most of the selectivity is obtained have transformers with the grid tapped down to minimize loading by the input resistance of the tube.

Gain at 20 mc is about 100 db and the stages are carefully shielded and isolated with filter resistors and filament chokes to prevent any regeneration. A gain control is incorporated in the screen grid and plate circuits of the first and second IF stages. The detector is of the infinite impedance type.

Where an IF gain of 110 db or more is required, it is advisable to use a double-frequency IF amplifier to secure stable operation. Several experimental amplifiers having a first IF of 20 mc and a second IF of 4.3 mc have been constructed which give gains of 115 db with complete freedom from regeneration. Since it is often necessary to advance the IF gain to a point where the small sidelobes of a spectrum can be studied properly, the first IF image rejection should be about 60 db in a double-frequency design.

Video Amplifier

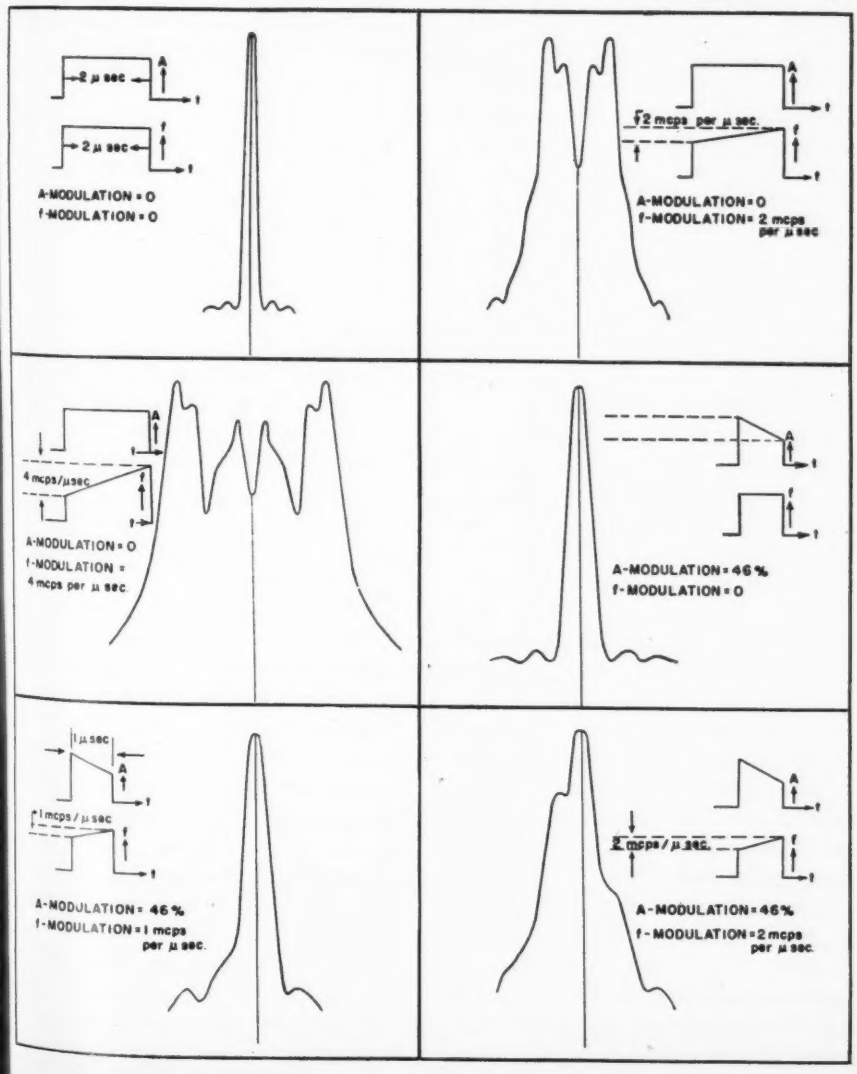
The video amplifier response must be flat to well below 10 cycles per second to preserve the frequencies involved in sweeping the local oscillator at 10-20 cps. For this reason the time constant of the coupling networks is in the region of 1 second. High frequency response is required only to the extent that it is necessary to reproduce the sharp rise and fall of the trace on the cathode ray tube as the viewed oscillator is pulsed; the amplifier is flat to 20 kc.

Provision is made for viewing the crystal current wave on the cathode ray tube to assist in setting the local oscillator to the proper mode of oscillation and to the proper frequency. The output of the local oscillator is rectified by the crystal mixer, amplified, and applied to the vertical plates of the cathode ray tube when the video switch is at position 2 in Fig. 4. As the local oscillator sweeps through the frequency to which the frequency meter is set, the sharp decrease in energy reaching the crystal mixer shows a dip in the crystal current curve. In normal operation (video switch at position 1), a differentiator produces from this dip a sharp frequency meter "pip" which is then superimposed upon the signal from the IF amplifier. By this means the frequency of any side lobes or other detailed characteristics of the spectrum may be determined. In all frequency measurements it is, of course, necessary to determine whether the signal components being viewed lie 20 mc above or 20 mc below the local oscillator frequency.

The main power supply produces an output voltage of 700 volts, 400 positive and 300 negative, with respect to ground. A second rectifier with its filter network supplies 1,000 volts negative with respect to ground for operation of the cathode ray tube. An electronic regulator circuit provides a regulated voltage of 120 volts to the IF amplifier, and a second regulator system maintains the negative voltage bus bar at —300 volts with respect to ground. In addition, gas-filled voltage regulator tubes supply —450 volts to the reflector of the local oscillator tube. The cathode of the latter tube is operated at —300 volts, with the grid at ground potential.

One of the principal uses of the spectrum analyzer is to view the output of a radar system to make

Fig. 3—Diagrams of some commonly encountered spectra, showing the effect on the output spectrum of deviations from a perfectly rectangular pulse shape



certain that its energy is not being distributed over too wide a band of frequencies. It is important that the center frequency lobe contain most of the power within the bandwidth of the radar receiver or a loss in performance will result. A typical good spectrum is shown in Fig. 5-A, while Fig. 5-B shows a bad spectrum resulting from excessive frequency and amplitude modulation of the pulse applied to the oscillator tube. A considerable amount of the power of the oscillator with the band spectrum is outside of the radar receiver's bandwidth, which is generally designed to be only slightly greater than the width of the center lobe under ideal pulsing conditions.

Practical Uses

The frequency width of the center lobe can be measured by use of a wavemeter marker pip on the higher frequency model, and by a series of marker pips with one mc spacing from a self-contained oscillator on the lower frequency model. Appropriate steps for correcting the modulator of the radar can be taken while viewing the resulting spectrum.

A second use of the spectrum analyzer is the determination of

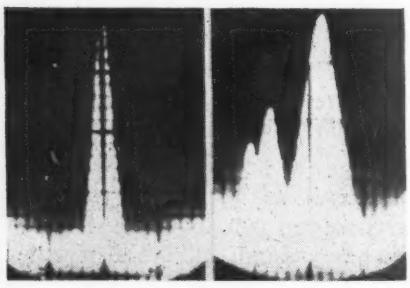


Fig. 5—A, (left), screen picture of nearly perfect rectangular pulse and B, spectrum of oscillator driven by inferior pulse showing introduction of additional lobes and frequency spread

the frequency of a pulsed oscillator. By means of the wavemeter attached to the plumbing of the higher frequency model, the frequency of the oscillator can be determined. Measurement of frequency with the lower frequency model is accomplished by feeding a cw signal of known frequency into a second input of the analyzer and superimposing it on the spectrum of the signal being observed.

The spectrum analyzer may be used to adjust the local oscillator

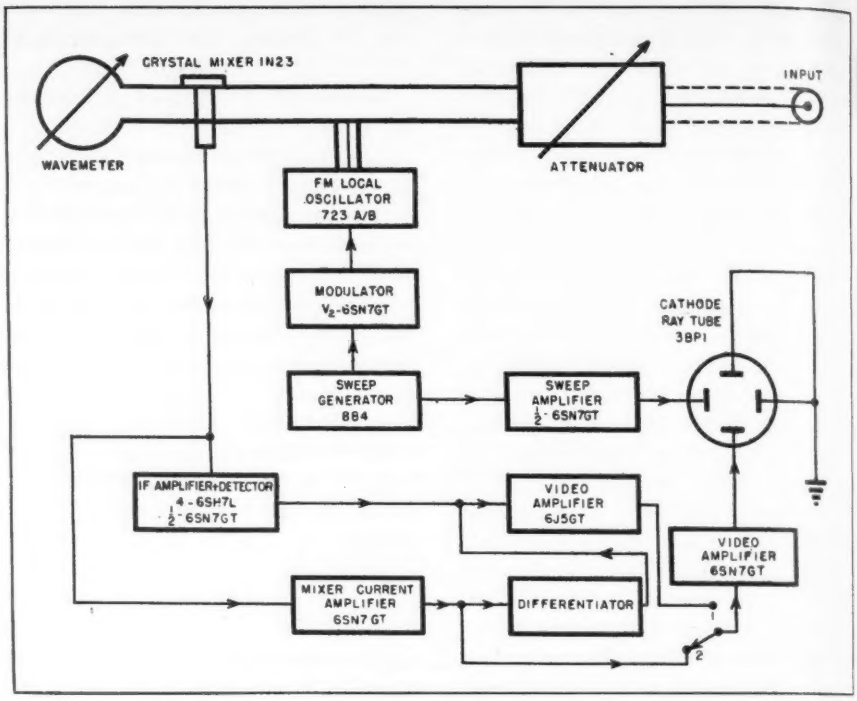


Fig. 4—Block diagram of 9,300 mc analyzer; 3,000 mc analyzer is similar

frequency of a radar receiver to space it properly with respect to the transmitter frequency. The analyzer is coupled to the radar system so that both the transmitter spectrum and the cw signal of the local oscillator appear simultaneously on the cathode ray tube. The frequency difference can be measured as outlined above, and the local oscillator adjusted while watching the pattern on the screen until it is removed from the transmitter by exactly the IF of the radar receiver.

Checking Radar Circuits

The operation of the AFC circuits of the radar system can also be checked by observing whether or not the frequency of the local oscillator of the radar varies in synchronism with that of the transmitter. In some cases, the local oscillator tubes to be used in radar receivers of systems in the 9,300 mc region were simply substituted for the local oscillator tube of the spectrum analyzer, and adjusted roughly to frequency by watching their crystal current output curves on the analyzer with the wavemeter pip superimposed.

The instrument may also be used to check pulling or shifting in frequency of a pulsed oscillator in a radar transmitter by observing the spectrum while the spinner or antenna is in motion. One may thus determine, in the case of excessive pulling, the position of the spinner at which the undesirable impedance causing the trouble is presented to the oscillator.

The spectrum analyzer may be used as a sensitive detector in conjunction with a slotted section to measure large standing wave ratios.

The spectrum analyzer can be adapted for other uses as required by specific application. It is possible to change the frequency band in many cases by substituting appropriate local oscillators and plumbing components. The attenuation of various rf components may be checked. Wavemeter calibrations may be checked by modifying the plumbing slightly.

Molecules Absorb 1-cm Waves

In a letter to the editor, published in the December, 1946, issue of the *Physical Review*, C. H. Townes, A. N. Holden and F. R. Merritt of Bell Telephone Laboratories, report rotational absorption spectra of several linear molecules in the 1-cm region. The gaseous compounds are present in a 4-meter length of waveguide and absorption lines between 23,000 and 25,000 megacycles are observed on an oscilloscope. Molecular data may be inferred from these measurements.

Underwater Sound Propagation

Studies by the Navy at New London in location technics reveal channeling of sound waves in accordance with water temperature and depth

• Originally discovered by Prof. Ewing and greatly developed by the Underwater Sound Laboratory of the Navy at New London, the channeling of sound waves in the ocean at depths between 300 and 400 feet in the Atlantic and between 600 and 700 in the Pacific furnishes an excellent new tool for locating lost airships at sea or for other similar purposes.

The technic is to set off a 4 lb. bomb at the appropriate depth and to receive the sound at great distances by means of a hydrophone equipped with an amplifier. For example sound energy from bombs dropped from an airplane between Bermuda and the Azores was received at Eleuthera in the Bahamas, the distances ranging to 1620 nautical miles. Reception on a hydrophone at such a range is like the approaching rush of an express train and the noise volume puts the needle well off scale on a standard VU level meter.

The temperature of sea water fluctuates over a fairly narrow range near the surface and then decreases quite steadily as depth increases until a temperature of 4 deg. C. is attained. Below this point, the temperature no longer varies (Fig. 1). The pressure of water, on the other hand, increases steadily with depth (Fig. 2). The effect of these variations is to cause the velocity of sound transmission to follow a curve as shown in Fig. 3, reaching a minimum at the critical depth.

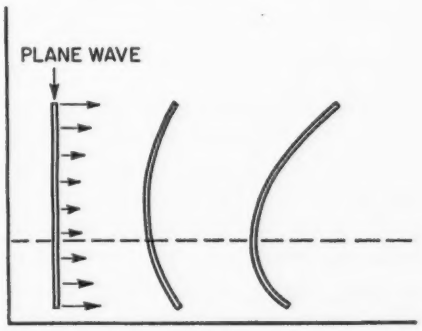
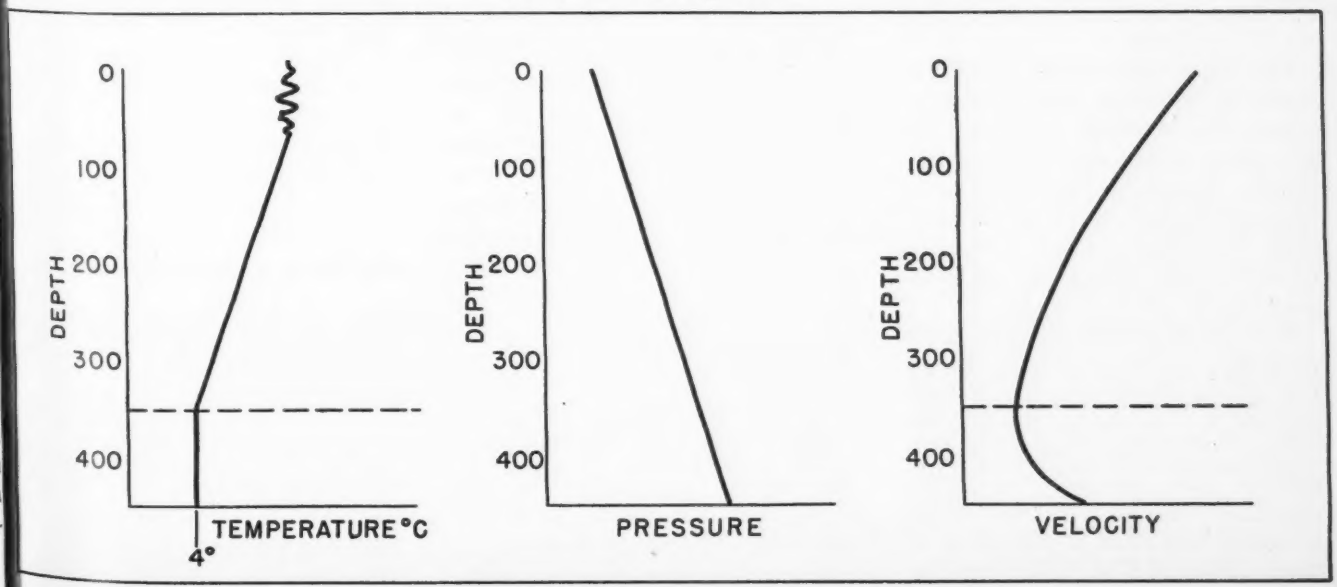


Fig. 4—Refraction of plane wave toward a sound "channel" at the critical depth

As can readily be seen, a plane wave front traveling through the water will be distorted, the upper part and lower part traveling at a higher velocity and going ahead of the middle part. Thus there exists refraction of the wave toward a sound "channel" at the critical depth (Fig. 4).

The hydrophones used have a fairly even response curve and a sensitivity such that when placed in a sound field of 1 dyne per cm², their electrical output is 100 to 110 db below 1 volt, or about 10 microvolts.

Figs. 1, 2 and 3—How water temperature varies with depth; pressure variation with depth; and critical depth at which most valuable channeling occurs



An RC Circuit Giving Over-Unity Gain

By CONRAD L. LONGMIRE
Univ. of Rochester, Rochester, N. Y.

Describing an arrangement of components that will give a voltage boost at a particular frequency, with a discussion of several applications

• RC networks are used frequently in vacuum tube circuits as frequency-selective devices. A familiar example is the Wien bridge network, which furnishes the basis of vacuum tube oscillators, or the three-section RC line or filter, to give at one particular frequency a phase shift of 180°. Use of this network to provide feedback from plate to grid of an amplifier tube will result in sustained oscillation at this frequency if the voltage gain of the tube balances the attenuation in the line.

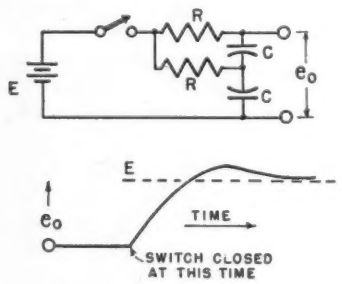


Fig. 1—RC network giving overshoot at e_0. Below, transient response curve

The voltage gain of each of these networks is somewhat less than unity. The same statement is true for many other common RC networks. Although this peculiarity need not be a disadvantage, it is at least interesting to try to devise a network with voltage gain greater than unity.

If one considers the transient response of the network shown in Fig. 1, it is obvious that the output voltage, e_o, overshoots the battery voltage, E, because during the first part of the transient the upper capacitor receives a charge which it cannot lose until e_o exceeds E, so that current can flow from right to left in the top resistor. Because of this "resonance" effect, one might suspect that at some frequency the voltage gain would exceed unity.

THE author performed this brief analysis and experiment mainly because of an interest in the possibility of devising an RC circuit with "resonance" characteristics. By example, such circuits do exist, and may be useful in some of the many applications of electronic circuitry.

To investigate this, write the loop equation in terms of the currents shown in Fig. 2. The equations are:

$$I_1\left(2R + \frac{1}{j\omega C}\right) - I_2 R = 0$$

$$-I_1 R + I_2\left(R + \frac{1}{j\omega C}\right) = E$$

Solve for I_1:

$$I_1 = \frac{ER}{R^2 - \frac{1}{\omega^2 C^2} - j\frac{3R}{\omega C}}$$

Multiply I_1 by R and subtract from E to find E_o. Then voltage gain =

$$\frac{E_o}{E} = \frac{1 + j3R\omega C}{1 - R^2\omega^2 C^2 + j3R\omega C} \qquad (1)$$

The absolute value of this expression is greater than unity in the region, $0 < R\omega C < \sqrt{2}$, and throughout this region there is a phase lag different from zero.

Now, if the resistors and condensers are interchanged in the circuit as shown in Fig. 3, the new voltage gain can be found by replacing R by $\frac{1}{j\omega C_1}$ and $j\omega C$ by $\frac{1}{R_1}$ in Equation (1).

This yields

$$(\text{gain})_1 = \frac{1 - j\frac{3}{R_1\omega C_1}}{1 - \frac{1}{R_1^2\omega^2 C_1^2} - j\frac{3}{R_1\omega C_1}} \qquad (2)$$

Now imagine that these circuits are cascaded but that the second circuit does not load the first appreciably (the second may be of much greater impedance than the first) and let us find the condition for zero phase shift through the networks.

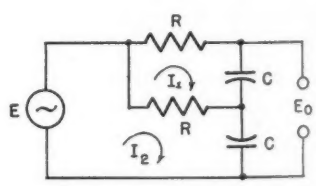


Fig. 2—Direction of currents in eq. 1

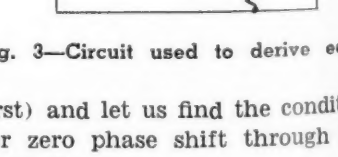


Fig. 3—Circuit used to derive eq. 2

The total voltage gain is the product of the two gains given by Equations (1) and (2). The total gain will be a real quantity (with no phase shift) if, and only if, these two gains are complex conjugates.

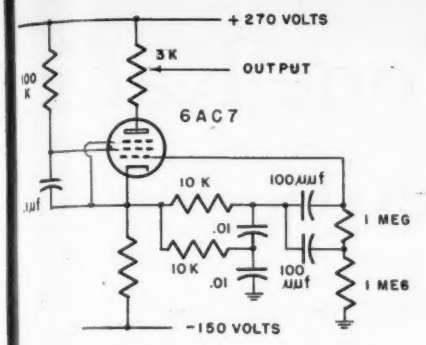


Fig. 4—Cathode follower type oscillator using positive gain RC circuits

apart from a multiplicative constant. By comparison of Equations (1) and (2) this condition is fulfilled if, and only if,

$$R\omega C = \frac{1}{R_1\omega C_1}$$

that is, if

$$\omega = \frac{1}{\sqrt{RC\ R_1C_1}} \qquad (3)$$

In this case

$$\text{total gain} = \frac{1 + 9\frac{RC}{R_1C_1}}{\left(1-\frac{RC}{R_1C_1}\right)^2 + 9\frac{RC}{R_1C_1}} \qquad (4)$$

The total gain is greater than unity for $0 < \frac{RC}{R_1C_1} < 2$, and has a maximum value of about 1.16 for

$$\frac{RC}{R_1C_1} = .373 \qquad (5)$$

If Equations (3) and (5) are used as design equations, there are still left two variables to choose freely. One of these choices can be used to make the impedance of the second network much greater than that of the first, to prevent loading, and the other choice can be used to meet some impedance condition imposed by an associated circuit.

The Cathode-Follower Oscillator

To simplify calculation, let $R_1C_1 = RC$. Then $\omega = 1/RC$ and the total gain $= 10/9$. If we have a cathode follower with gain greater than 9/10, and if the network is used to give feedback from cathode to grid, oscillation at a frequency of $1/2\pi RC$ should occur.

To make a cathode follower with gain near unity, a high-g_m pentode was used with the screen bootstrapped to the cathode, and with the operating point selected in a region where the g_m was high. The circuit constants are shown in Fig. 4. R for the first network was chosen as high as 10K in order not to load down the cathode follower. Picking C as .01 mfd should then give a frequency of 1590 cps. In order to make the impedance of the second network 100 times that of the first, R_1 was chosen as 1 meg., and C_1 as 100 mmfd. An electron-coupled output was obtained in the plate circuit.

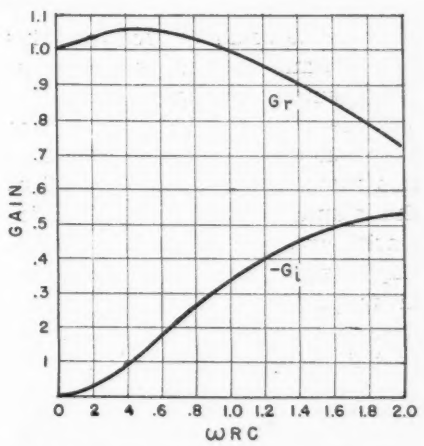


Fig. 5—Real and imaginery parts, G_r and G_i of network 2 plotted vs. ωRC

When connected as shown in Fig. 4, the circuit produced oscillations at a frequency of 1540 cps. as measured against a Hewlett-Packard test oscillator. (The components used were correct to 10 per cent.) The maximum output was 8 volts rms. No attempt was made to determine accurately the stability in frequency or the harmonic content. Ordinary composition resistors were used. The frequency stability seemed to be of the order of 1 cps. for 10 per cent change in heater voltage or 2-volt change in the B-supply. There was no apparent harmonic content by observation of the waveform on an oscilloscope.

No advantages are claimed at present over other RC oscillators. The number of components in the frequency-determining network is by no means a minimum.

Fig. 5 shows the real and imaginary parts, G_r and G_i, of Equation (1), the voltage gain of the network shown in Fig. 2, plotted as a function of ωRC.

Now let the network be used to give feedback from cathode to grid of a tube, with provision for bias, as shown in Fig. 6, and apply an external voltage E of angular velocity ω between cathode and ground. For ω such that $0 < \omega RC < 1$, the component of grid voltage in phase with E is very nearly equal in amplitude to E, the cathode voltage. Therefore only a small in-phase component of currrent flows through the tube. However, the out-of-phase component of grid voltage does cause an appreciable out-of-phase current through the tube, of amplitude approximately equal to $E \times G_i \times g_m$. This current leads E by 90°, as in a capacitor. The tube therefore presents an effective capacitance, C_e, such that $E \times G_i \times g_m = E\omega C_e$, or

$$C_e = \frac{g_m G_i}{\omega} \qquad (6)$$

In the region around $\omega RC = 1$, G_i/ω is approximately constant so that $C_e \sim g_m$. The effective capacitance can be varied by varying g_m by, for instance, controlling the grid bias or the screen voltage.

The real part of the gain, G_r, has a maximum slightly greater than

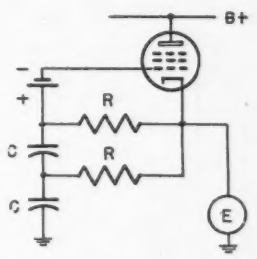


Fig. 6—Cathode to grid feedback net

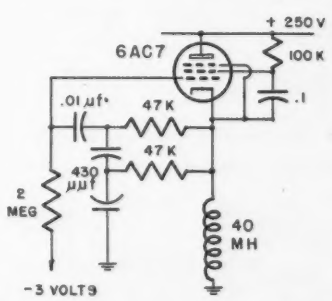


Fig. 7—Network giving oscillations

unity at $\omega RC = \frac{1}{2}$. At this point the cathode may present a negative resistance small enough to more than cancel the positive resistance seen looking into the network. In fact, if an inductance is connected

(*Continued on page* 112)

Multi-Channel Two-Tone Radio Telegraph Developments

Recently perfected methods of applying voice-frequency carrier-telegraph systems to radiotelephone circuits—24 tones on single channel

● **Confronted with the need for increased telegraph communication channels between strategic points the Bell System is now applying voice - frequency carrier - telegraph systems to radiotelephone circuits.**

Tests first applied by the operation of a standard VF telegraph system on a channel of a twin single-sideband radio system indicated this was impracticable, because the received tone of one channel of a VF telegraph system operating over such a radio channel, fluctuates over a range of 20 or 30 db from instant to instant.

Automatic volume control would partially compensate for such level fluctuations. In the standard VF telegraph system, a single tone is used for each channel, the tone being connected to the circuit for dots and dashes (commonly called marks), and removed for spaces. If a volume control were made fast enough to follow the very rapid fading that is sometimes experienced, the noise during spaces would be amplified to the same level as the signals, and thus no intelligence could be received. This sets a limit on the possibility of improvement by such means.

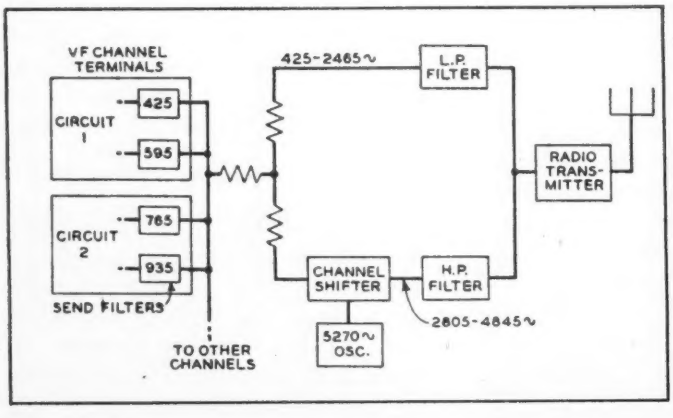
These considerations led to the adoption of a two-tone transmission instead, where one channel of the standard system is used for marks and an adjacent channel, employing a tone 170 cycles higher in frequency, is used for spaces. Here the amplitude of the transmitted signal is substantially constant, and a fast-acting gain-control device may be used without danger of raising the noise to the level of the signal.

With the limiter the circuits were good enough for automatic transmission of International Morse code, in which the received dots and dashes are recorded on a paper tape, but considerable further improvement was desired for teletypewriter transmission, because even with the limiter, deep selective fading would at times reduce the signals below the noise level. A receiving operator can use judgment in interpreting the message, but a teletypewriter cannot use judgment, and better transmission is consequently required.

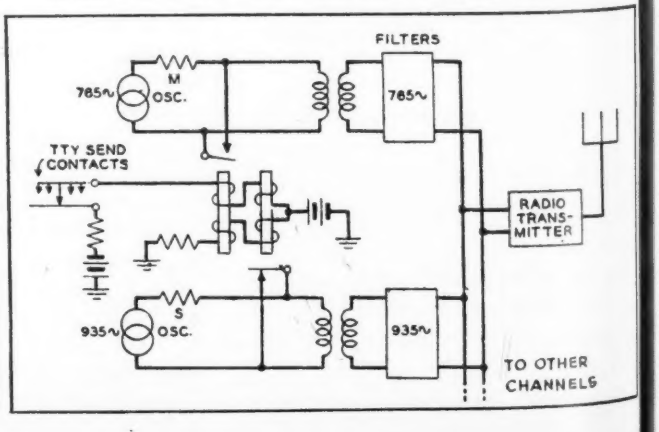
It is a well-known characteristic of selective fading that when a signal received at one frequency has faded so that it cannot be detected because its intensity is less than that of the noise or static, a signal at a frequency only a few hundred cycles away is usually being received at a much higher level; and by the time this second frequency has faded, the first will generally have returned to a usable value.

This "frequency-diversity" system was tried and the improvement was outstanding. The sending relays of two channels carrying frequencies that differed by about 1,000 cycles were connected at the sending end so that the same two-tone signals were sent out simultaneously on two pairs of frequencies. The detectors at the receiving end were connected to a single receiving relay, and now the circuit was satisfactory for multi-channel teletype operation. Standard voice-frequency carrier-tele-

Transmitter terminal for two-tone teletypewriter circuit

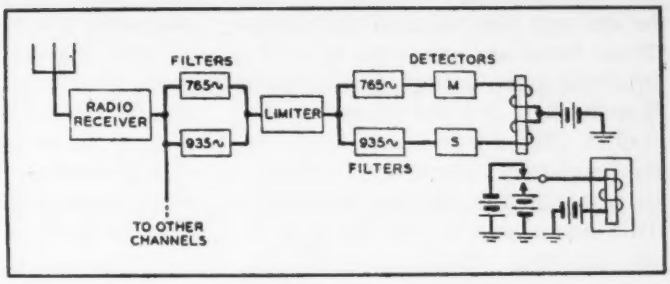


Terminal circuit for 6 two-tone radio telegraph channels



graph equipment was modified for two-tone operation.

The circuit arrangement for one channel of this system is indicated in the first two illustrations. On a marking pulse, the transmitting relay short-circuits the 935-cycle supply and allows the 765-cycle supply to pass to the radio transmitter, while for a spacing pulse the reverse action takes place. At the receiving end, band-pass filters select the two frequencies for this channel and pass them to the limiter. At the output of the limiter, similar band-pass filters select the two frequencies and pass them to separate detectors, the outputs of which operate the receiving relay.



Arrangement of receiving terminal used for two-tone work

Increasing Capacity

Each such system provides six two-tone circuits for use with International Morse code with Boehm recorders for receiving. To obtain teletypwriter circuits, however, two of these two-tone circuits had to be used for each message, and then there were only three channels per system. Some means were therefore sought to increase the number of telegraph messages that could be transmitted over a single radio channel.

A channel shifter, that was used on radio circuits to move the voice transmission from the lower frequencies to the upper frequencies of one channel of a single-sideband circuit, provided means for transmitting six channels of the frequency-diversity telegraph system —twenty-four tones—over a single radio channel without requiring much additional equipment.

The arrangement of the transmitter is illustrated. Outputs of six two-tone telegraph circuits, and a single-tone circuit used as an order wire, are connected together and then passed through a resistance network to a two-branch circuit—all frequencies flowing equally into each branch. Along the upper branch they pass directly to the radio transmitter through a low-pass filter that passes all frequencies below about 2,600 cycles. Along the lower path, they enter the shifter circuit, where they are modulated with the current from a 5,270-cycle oscillator. A balanced copper-oxide modulator is employed that eliminates the carrier, and the upper sidebands are eliminated by a low-pass filter in the shifter. The lower sideband frequencies, which are higher than those in the upper branch, are then passed through a high-pass filter to the radio transmitter.

The twelve frequencies from the six two-tone telegraph channels are spaced 170 cycles apart from 425 to 2,295, inclusive, and the order-wire frequency is 2,465. The lower sideband frequencies resulting from the modulation of these frequencies in the shifter with 5,270 cycles are spaced 170 cycles apart from 4,845 to 2,805.

The radio transmitter thus transmits thirteen frequencies spaced 170 cycles apart from 425 to 2,465 cycles and a corresponding set of thirteen frequencies from 2,805 to 4,845. Each teletype signal pulse is represented in this group by two frequencies. Thus, a marking signal for the No. 1 teletypewriter circuit is represented by frequencies of 425 and 4,845 (5,270-425), while a spacing signal for the same channel is represented by 595 and 4,675 (5,270-595) cycles, and so on for the other five channels.

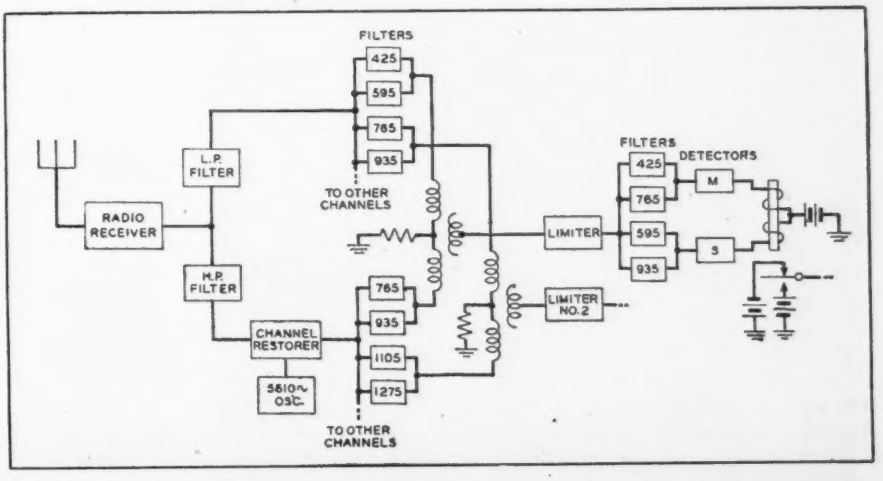
If selective fading over the radio path should drop out the radio frequency corresponding to 425 cycles, the same information would nearly always be carried on to the receiver by the radio frequency corresponding to 4,845 cycles, which is about 4,000 cycles higher.

Fading Eliminated

Variations in the radio path cause large changes not only in signal strength but also in the phases of the alternating currents received. At the receiving end, therefore, if the 4,845-cycle current were restored to 425 cycles and combined with the 425-cycle current transmitted directly without being shifted in frequency, the two currents would reinforce each other at times, but at other times they would tend to cancel each other. To avoid this cancellation, the frequencies that were shifted to higher values at the transmitter are restored to frequencies differing from their original values by modulating with an oscillator frequency of 5,610 cycles instead of 5,270.

Thus, an original frequency of 425 cycles, which is changed by the shifter of the transmitter to 4,845 cycles, is restored at the receiver not to 425 but to 765 cycles. The corresponding spacing signal of 595 cycles would be restored to 935 cycles. At the receiver, therefore, the two pairs of frequencies

Receiving terminal for multi-channel two-tone radio teletypewriter transmission

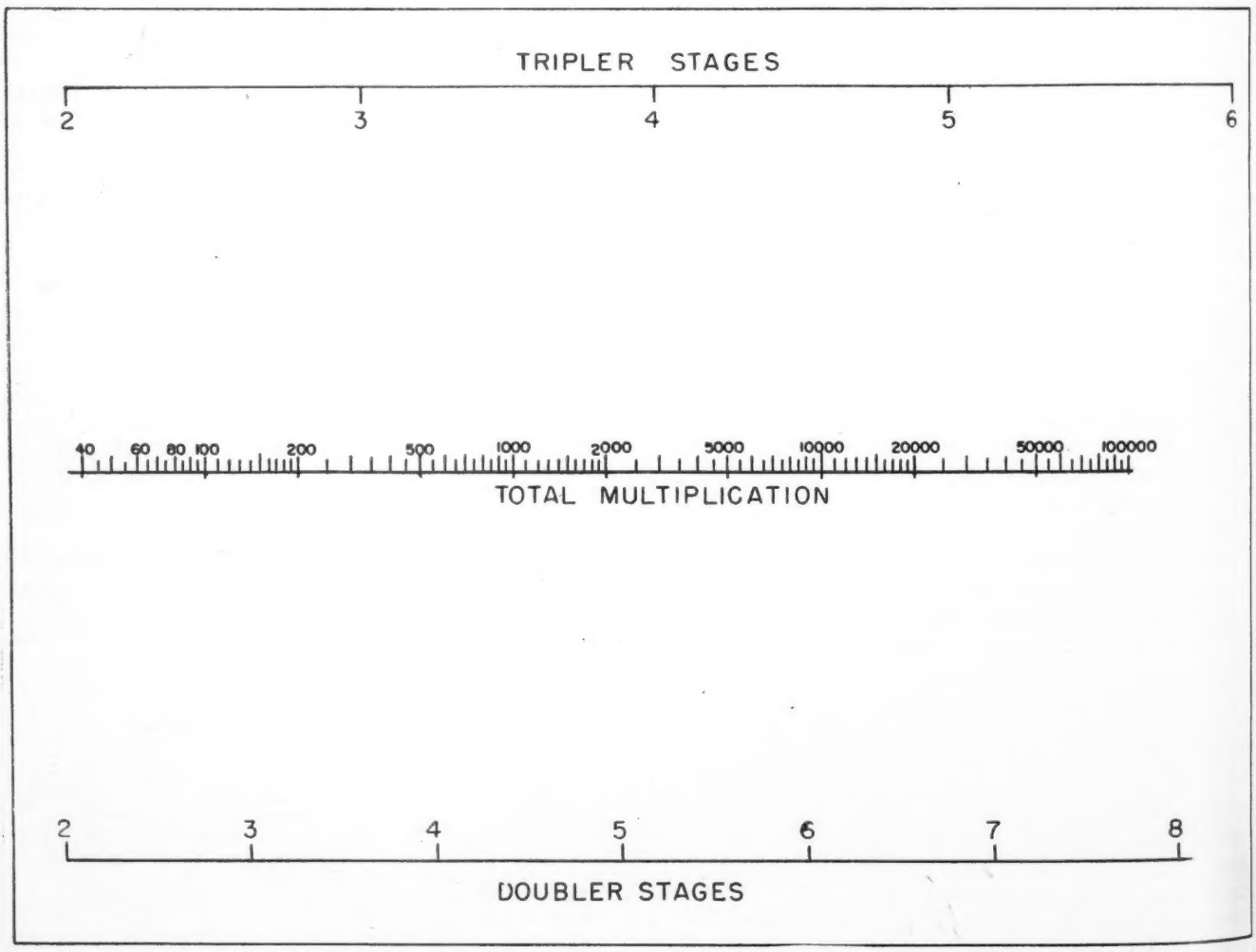


for this particular channel would be 425 and 595, 765 and 935 cycles. These tones are combined in a hybrid coil, and amplified in a common limiter. At the output of the limiter, they are once more selected by band-pass filters and rectified in marking and spacing detectors. This arrangement thus provides a six - channel frequency - diversity system without the duplication of detectors or the development of new filters.

At the receiving end, therefore, the circuit is arranged as indicated schematically. At the output of the radio receiver, low-pass and high-pass filters separate the frequencies below about 2,600 cycles from those above it. The output from this low-pass filter is connected to the input of thirteen band-pass filters for the frequencies 425 to 2,465 cycles, inclusive, while that from the high-pass filter passes to a channel restorer, where the frequencies are modulated with the current from a 5,610-cycle oscillator. Channel filters in this branch then separate the various frequencies, and the pairs of frequencies from each branch corresponding to a single channel are combined in a hybrid coil and then amplified in a limiter. At the output of the limiter are four channel filters. Two of them select the two frequencies corresponding to marking signals and pass them to the marking detector, and the other two select the frequencies for the space signaling and pass them to the spacing detector. Although one frequency of a pair may have been eliminated by fading, the other will usually be present to operate the receiving relay.

This multi-channel two-tone system is capable of handling a large amount of traffic over a single radio-frequency assignment with comparatively low power per channel. Unlike other systems of large traffic capacity, it furnishes independent start-stop teletypewriter circuits which have maximum flexibility in that they can be readily terminated in teletypewriters of types in heavy production and general use, or extended over land lines to such machines at different locations by simple connections which permit use of standard forms of start-stop regenerative repeaters where these are necessary. Operation with narrow frequency bands for the individual channels was made possible by the inherent frequency stability of the single-sideband circuit. The system was designed and made available quickly, utilizing for the most part standard components. Abstracted from an article by L. C. Roberts in Bell Systems Record, November 1946.

GRAPH FOR FREQUENCY MULTIPLIER STAGES



FM systems usually require the extensive use of multipliers to secure high modulation indices and carrier frequencies. A line through the required multiplication factor extending to points on the top and bottom scales will indicate the possible number of multiplier stage arrangements that give the required total multiplication

Recording Oscilloscope Images

Beam splitter in camera for picturing radar scope patterns, permits simultaneous inspection and photography of screen images

• Of the many ingenious war born devices that have now been redesigned for peacetime applications, an interesting example is a camera originally developed by the Fairchild Camera & Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y., for keeping a permanent record of the continually changing images on radar scopes when installed on aircraft.

When used with an oscillograph, it will provide a record of the performance of equipment in production; such as the wave forms of electronic circuit components, the modulation characteristics of radio receivers and transmitters, etc. It can also be used as a single frame exposure camera in taking photographs of industrial recording instruments at predetermined varying intervals.

Oscillographs have the "perverse" habit of showing everything that happens, so that when those events change too rapidly to analyze visually it is necessary to get a photograph of the diagram at particular instants of time or under known conditions of operation, that are correlated with the mechanism or process under investigation.

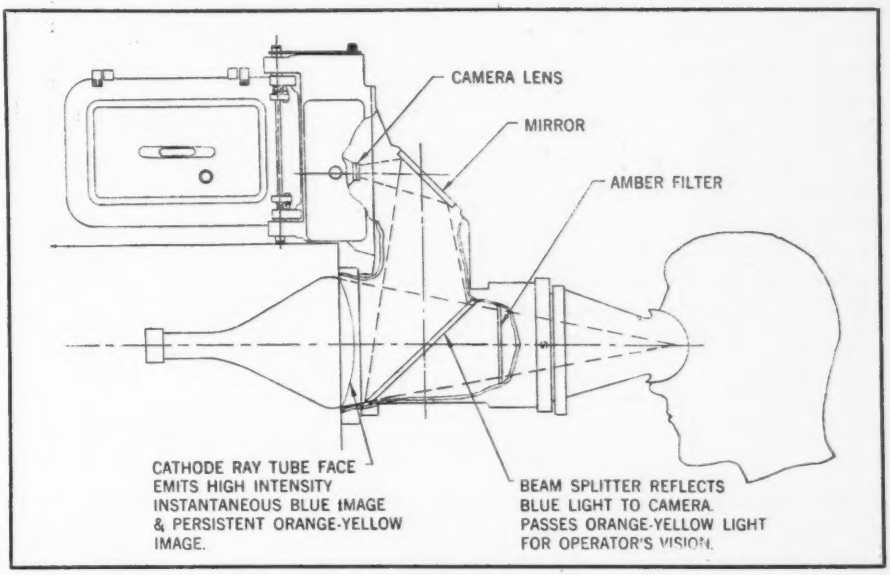
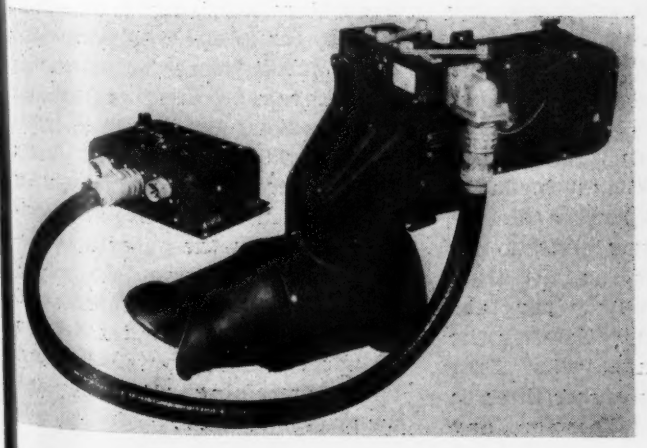
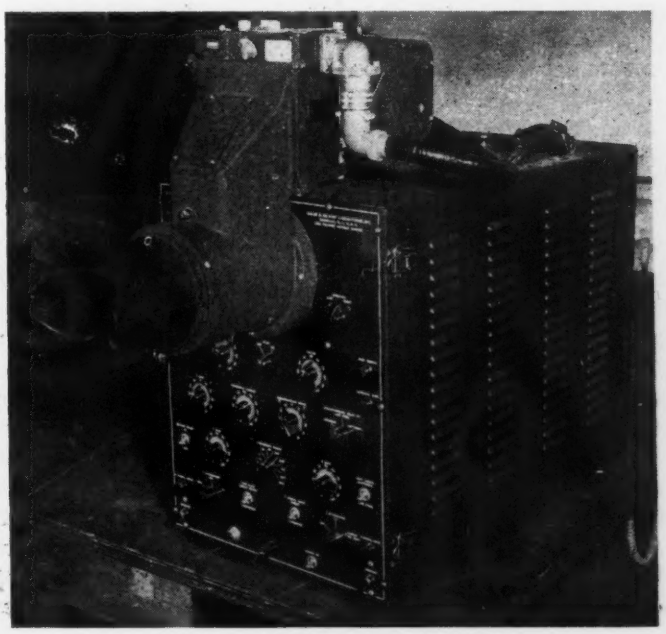


Fig. 4—Partly sectioned diagram showing the principle on which the camera operates and manner in which the beam splitter filter permits inspection while reflecting images to film

Fig. 1 is a view of this camera which is adapted to be attached to a regulation oscillograph. It will be noted that an unusual feature of this camera is that it permits simultaneous observation and photographing of a pattern. Fig. 2 is a wiring diagram of the record-

Fig. 1—A picture of camera equipment alone and at the right Fig. 3—The camera as it appears mounted on a scope





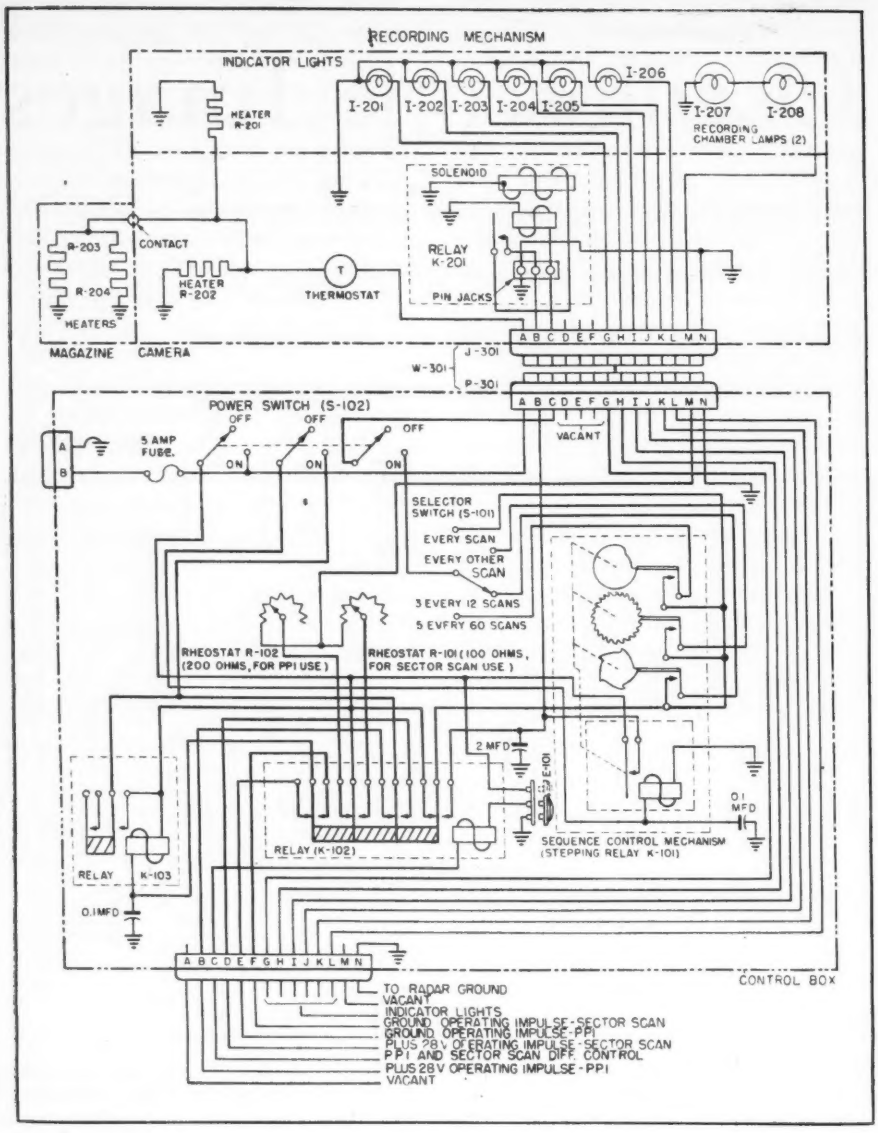


Fig. 2—Wiring diagram of camera recording mechanism and the control box of the recorder

ing mechanism, camera, magazine heater and the control box of the recorder, when used in radar photography, although the control mechanism governing the sequence schedule of photographing can be arranged to meet specific requirements for other industrial services.

The K-201 relay and the solenoid (units of the camera mechanism) control the film winding spring and the shutter action. Fig. 3 is a photograph of the camera mounted to record a cathode ray tube image. The position of the camera permits full access to the oscilloscope controls while the operator views the image as it is being photographed. Also, what is equally important light cannot enter by way of the viewing hood to fog the film, a feature made possible by the use of a color selective mirror called a "beam splitter". Fig. 4 shows the path of the oscillograph image, from the cathode ray tube screen to the recording film and the path of the operator's vision. This system utilizes the particular features of the recent double-coated cathode ray tube screen (P-7 phosphor), which delivers both a highly actinic light of short duration when struck by the electrons of the ray, and a longer-lasting phosphorescent image which permits easier visual studies. The former is not of much use in visual work and the latter do not greatly influence a film.

The beam splitter reflects the barely-visible blue actinic light emitted by the cathode ray tube to the upper mirror. However the highly-visible orange yellow light passes through the amber filter to the viewing screen. Therefore, any stray orange yellow light that may reach the film by way of beam splitter reflection, does not appreciably affect the recording in the photograph.

The amber filter modifies the color of any external light that passes through it into the optical path from lens to film so that the film is relatively insensitive to light entering the viewing window.

The camera recording chamber carries a clock, a data card, a counter and six small indicator lights. The lights, by their recorded position on the film, will record desired variables to a total of 64 different indications. These lights were, in the original radar scan recording application, controlled by successive revolutions of the radar scanning mechanism. The counter indicates the number of records taken and the clock shows the time each record is made. The control of the lights and the frequency of photographing can be governed as required for the particular application of the camera. The camera will take 1600 35 mm pictures without reloading.

Electronic Patents of 1946

During 1946, the U. S. Patent Office granted over 2,000 patents in electronics. This large collection of new design and manufacturing knowledge is now made available in convenient form, in the Electronic Engineering Patent Index published this month by the Electronics Research Publishing Co., 2 West 46th Street, New York, N. Y.

The first compilation of electronics patents to appear, this Patent Index contains all the electronics patents as illustrated and described in the 52 weekly issues of the "Official Gazette of the U. S. Patent Office," for 1946. The book is in photo-offset; hence the patents included are reproduced as published in the official Patent Office publication. The new Patent Index makes these 2000 or more entries available in one convenient volume, in which the patents are arranged under appropriate subject sections. A table of contents and an exhaustive cross-index are also included. The book is cloth-bound, 7 x 10, containing 480 pages, and the price is $12.50.

Determining Drift by Doppler

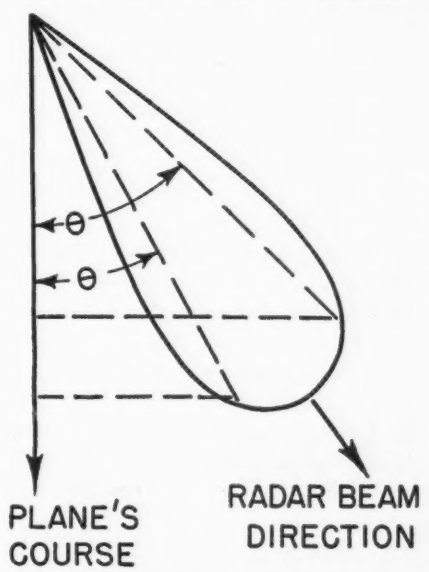
Using a pulsed beat method it is possible under certain circumstances to determine accurately the true course of an airplane over the ground

• An interesting use of airborne radar sets of the APS 10 or 15 type for the determination of the true course of an airplane over the ground was revealed in a paper given by Ivan A. Greenwood of the General Precision Laboratory before the Eastern Regional meeting of the Institute of Navigation in New York, February 14.

The principal instrument needed to make use of the method is a piece of blue filter glass which screens out the long persistence yellow phosphorescence of the radar PPI screen and permits the observer to see the blue short persistence trace more clearly. If the rotary scanning of the antenna is stopped while the antenna is pointed nearly in the exact direction of motion of the plane, it is noted that the blue short persistence radar return flash on the screen is intensity modulated. As the antenna is turned slightly to one side or the other this intensity modulation changes in speed, reaching a minimum when the antenna is pointed exactly in the direction the plane is traveling over the ground. Inasmuch as this minimum is quite sharp it can be located fairly easily. Since the airplane's heading is known, the drift can be obtained by simple vector subtraction.

The speed of modulation at the minimum point is around 2 to 5 cycles per second, a speed which is well within the most sensitive range of the eye. In order to make use of the method it is necessary to add a servo mechanism to the antenna to enable the operator to determine its heading accurately. In this connection the Bendix AY 100 series synchros have been found to give good results, having an accuracy of about 1/3 degree.

The sensitivity of the scheme is found to be inversely proportional



Manner in which energy returns from right and left side varies slightly, permitting use of Doppler effect in airplane tracking

to the antenna size. A major defect is that over water the arrangement fails to work due to the presence of too much sea clutter. It also fails in mountainous territory and very flat hot desert lands. In ordinary country however it permits results to be obtained within 1 to 4 degrees.

Referring to the illustration, if the airplane is headed in the direction of the arrow and the beam from the radar set is directed to one side, it may be seen that the returning energy from reflecting objects on the right side of the beam has its frequency altered, due to the well-known Doppler effect, to a greater extent than the returning energy from the left side of the beam. This is because the component of the airplane's velocity in the direction along the right side of the radar beam is greater than in the direction along the left side. Consequently the two energy returns undergo slightly different frequency modifications according to the formula

$$\Delta f = \frac{2v\cos\theta}{c} f^*$$

(v being the plane velocity, f radar set frequency, c the velocity of light, Δf the change in frequency of the returning energy and θ the angle between the energy return and the plane's course.) They thus beat with each other producing the intensity modulation previously described. When the beam is pointed along the true ground track, however, the difference in return frequencies is naturally reduced to a minimum.

*This formula is an approximation. For light and electromagnetic propagation, the true frequency shift is given by

$$\Delta f = f\,\frac{1+\frac{V}{C}\cos\theta-\sqrt{1-\left(\frac{V}{C}\right)^2}}{\sqrt{1-\left(\frac{V}{C}\right)^2}}$$

Mackay Adds Three

Three new powerful coastal radiotelegraph stations are to be established by the Marine Division of the Mackay Radio and Telegraph Co. as part of a considerable expansion program. The new stations will be located in Kent, Washington (near Seattle), in Galveston, Texas, and at Kailua in the Hawaiian Islands.

Fig. 1—Front view of unit in a portable case, with battery box and loudspeaker mounted above receiver

Very High Precision

By S. Y. WHITE
202-09 43d Ave., Bayside, N. Y.

Unusual construction permits continuous bandspread, 25-point alignment, replaceable tank circuit, no wiring

• A design for a really good tunable receiver in the VHF range has two major problems, a mechanically precise dial and a stable oscillator tank circuit. A range of frequencies between 110 and 135 mc was obtained with this receiver by vigorous application of known methods of getting circuit precision. This is far different from the common method of "designing" circuits.

Designers trying to improve performance in this frequency range quickly conclude that almost everything must be radically re-designed. To find a 10 kc channel at 125 mc one needs many feet of dial space. The circuit can no longer be assembled from components. One must design the whole tank circuit as a unit, with trimming, tracking, aligning and temperature compensation built in originally. Only two inches of wire must serve all purposes, and since it should all be placed in the coil, we cannot wire in separate trimmers. When complete we seem to need imaginary components, with no physical size, and soon find there are no commercially available components that can be fitted into such a design.

Since the frequency is outside the range of conveniently-sized cavities we must start fresh with the coil and build up. Here for precise performance there are two schools of thought — make everything of quartz and invar for low drift, or use silver, mica and ceramic parts with built-in compensation.

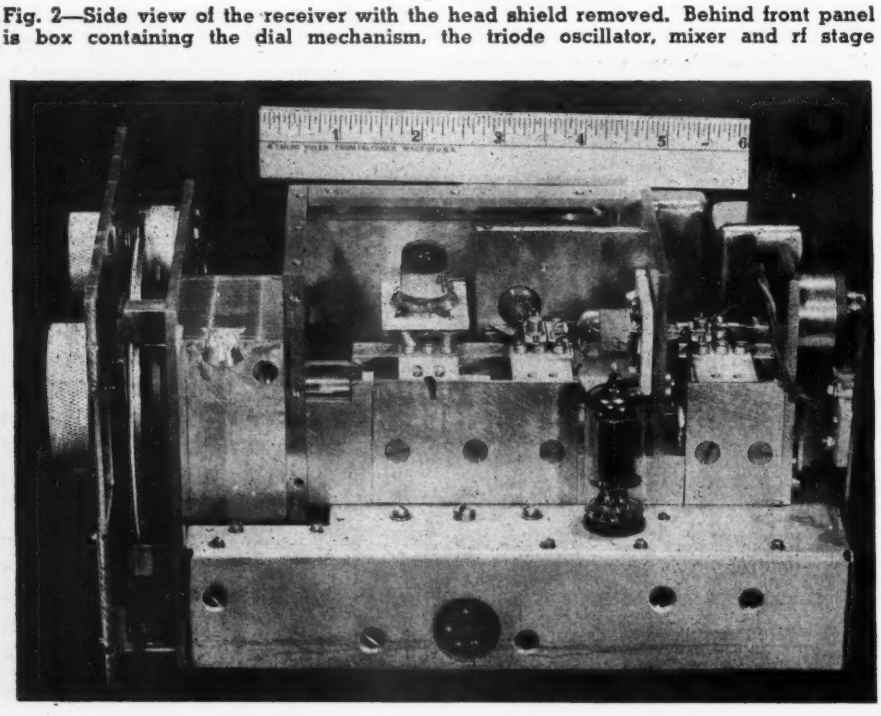
Permeability Tuning

A short excursion along the quartz-invar road has convinced the writer that the best classical construction is economically hopeless and the results are not too good; with the best components one must still use quite a bit of compensation.

Since permeability tuning was decided on, the coil was the basic unit affecting stability. It has been shown* that a Q of 700 is rather easily obtained with a coil of very high stability, having a ceramic compensating capacitor right across the terminals. In the mounting the Q falls to 400 for the assembly, but this is still quite satisfactory. A complete set of units was constructed, the lowest starting at 60 mc, the highest reaching 625 mc.

With a little design the tuning curve of "core movement frequency" was made close to absolute SLF over quite a range. Following this an experimental head unit, suitable for any frequency within 60 to 600 mc (by inserting the ap-

Fig. 2—Side view of the receiver with the head shield removed. Behind front panel is box containing the dial mechanism, the triode oscillator, mixer and rf stage



*Electronic Industries, "Superstability at UHF," Sept., 1943.

Tunable Receiver for VHF

propriate tank circuits) was constructed in the form of a portable (1½ v. tube) chassis to permit various checks on its performance. The head tuner was shock mounted through the controls, and at the back to prevent the tubes from being broken with rough handling, although the set was not microphonic to any degree.

Fig. 1 is a front view of the unit in a portable case, with a battery box and loudspeaker above. The antenna is an extensible steel rule pulled out to form a quarter-wave in conjunction with the case. The small knob is the volume control and switch. The large knobs are the tuning controls, one giving one mc steps, the other splitting each mc with a calibrated band-spread of exactly one megacycle.

Fig. 2 is a side view with head shield removed. Behind the front panel is the indicator portion of the dial, the box containing the dial mechanism, the triode oscillator, mixer and rf stage, respectively. The antenna coil is outside the shield. The tube in front is the audio output. The three tank circuits are complete interchangeable units held by pressure in a sturdy piece of channel of special cross section. The sheet metal chassis is attached to the head. A three stage IF (about 5 mc) is on the other side giving an IF sensitivity of 15 microvolts.

The cores are special iron, one-half inch long, with 0.200 in. hole making a snug fit for the ceramic rod which carries the three ganged cores. Cylindrical ceramic spacers are used between the cores for exact spacing. The cores are ⅜ in. OD.

The tank circuit is shown in some detail in Fig. 3. The upper left unit is a top view of the tank circuit assembly with three switch contacts (the two ends and a tap on the coil). The upper right unit is an unwound one-turn assembly ceramic form, showing deep grooves and joined to the flat plate by a high-temperature dust glaze and refired at about 1800°, providing a one-piece unit.

All coils (from one to five turns) have this same flat plate, and the same winding length, 0.375 in. center to center of the end turns, so that the movement of the tuning core is the same for each.

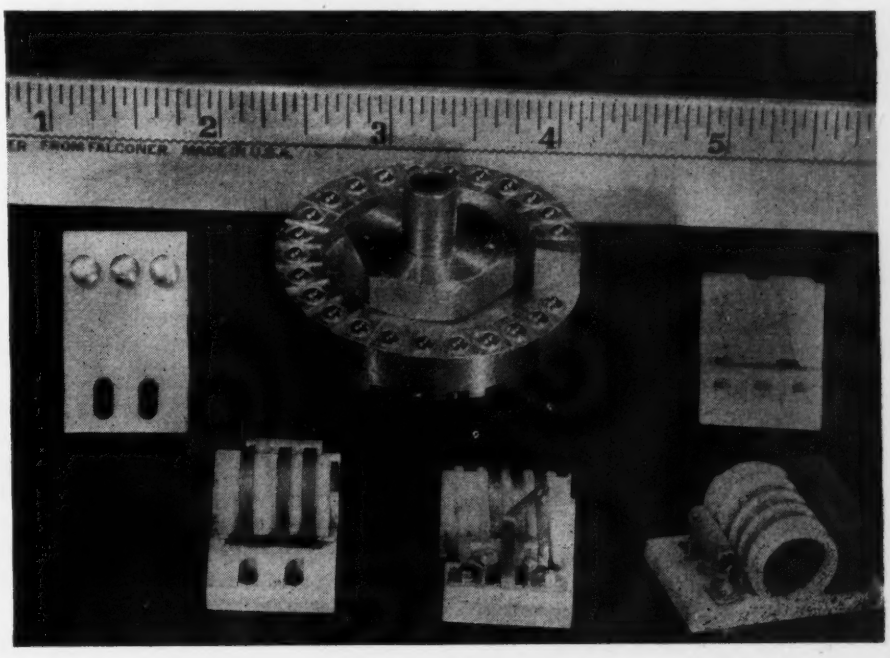
Concentrated Inductance

The lower right unit is a complete three-turn assembly. The coil terminates in massive low inductance blocks of silver, which also form a cradle for the tank capacitor of a cylindrical type, which is soldered direct to them. This seems the most compact tuned structure possible with about all of the inductance in the coil where it belongs, so that it follows one set of laws for temperature variation and vibration. It also concentrates all the inductance in a field that can be acted on by the iron core.

On the side of the coil opposite the tuning capacitor will be noted a large iron slug shaped to fit the coil contour. It is held by two screws that can be loosened so that the slug can be slipped, producing an effect equivalent to the usual padding capacitor. It has almost no effect when the core is outside the coil, but helps to complete the magnetic circuit when the core is fully within the coil. This shifts the slope of the tuning curve about 2% without affecting its SLF shape. This slug is adjustable by slightly loosening the screws while the receiver is being lined up with a precision frequency standard, and moving it with a special tool. The lower central coil assembly in Fig. 3 is a three-turn spiral winding with a 72-ohm antenna tap.

The first lower coil (Fig. 3) is an experimental coil wound with no pitch to each turn. This particular unit was made by turning rather thick coin-silver rings, splitting each ring and slipping it over the coil form so that it hugs the form. Short axial jumper connections place the turns in series, forming a coil. This tends to make the coil flux truly axial, and increases the SLF tuning range considerably. It was also a great help to be able independently to vary the distance between each turn to control the

Fig. 3—The tank circuit in detail, showing various parts described in the text Tuning slugs for coils are advanced by positioning of axial cam at center



rate of flux-pickup by the core, so the tuning curve could be made extremely close to absolute SLF.

Emphasis was placed on exact SLF tuning, because with a new type of dial construction this makes it possible to provide precise calibrations. We should like a dial of about one foot length per mc, since there are one hundred 10 kc AM channels per mc, giving about ten divisions per inch on the scale. An ideal system would be best accomplished by a step dial giving exactly one mc per step with an auxiliary dial with a lead screw splitting each mc of the range into the usual 10 kc points. This was actually accomplished with the system shown in Fig. 4.

Dial Indicator

The indicator portion of the dial is in the form of the usual dial disc-calibrated from zero to 1000 kc (the last zero being omitted). To avoid the rather annoying condition of coming up against a stop when working around an exact mc signal, about 100 kc is available above and below the one mc limit. Concentrically mounted around the disc is a step dial actuated by another knob through a gear. This dial has a detent action so it can be stopped only on an exact mc point which is shown through the mask (see Fig. 4) as a vertical line of figures. Since each click of the outer dial equals (in core travel or equivalent frequency change) a complete swing of the inner dial, we have a combined dial that is very long, rapidly set and easy to read. The dial can be shifted from any setting to another in about 4½ seconds. Fig. 4 shows a direct dial reading of 123,450 kc, with five significant figures.

This enormous readable scale length, working directly to five figure accuracy, requires unique performance from the dial mechanism. In usual practice a receiver is lined up at the factory by the trimmer at the high frequency end of the band, a padder at the low frequency end, and the tuning curve is on its own for intermediate points. It was found that with commercial tolerances on the coil form and tuning capacitor we could line the set up top and bottom to five place accuracy, but that some random variations in the tuning curve from exact SLF required many more correction points. The obvious solution was to align the set at every mc point. In the following discussion we will discuss accuracy only from the viewpoint of oscillator setting, since the rf circuits are pretty broad due to tube loading.

At around 125 mc it was fairly easy to design the circuits and cores for a constant 10 mils movement per mc, equivalent to a core motion of a ten-thousandth of an inch for each 10 kc band.

A 75-pitch screw, so that 240° rotation gives 10 mills of motion, is not too hard to make, since only one turn is effective. The principle design was in the clamp-down mechanism at each end to minimize backlash. Monel against bronze was found to be a good combination. The complete design resulted from the following reasoning: since this screw can tune only from 110 to 111 mc. for example, a 10-mil spacer placed between the screw and the pushrod on which the cores are mounted, would push the cores back exactly one mc. and the screw would then tune from 111 to 112 mc.

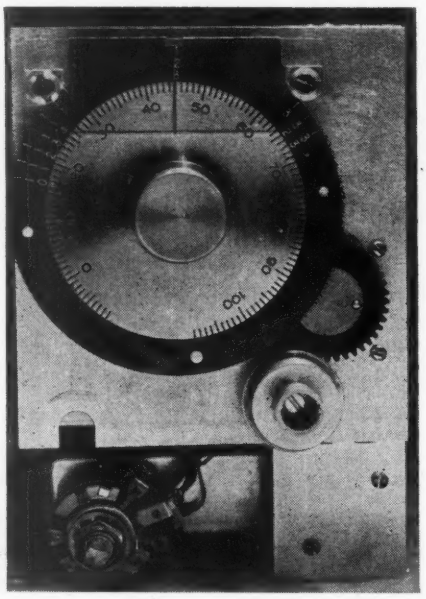


Fig. 4—Tuning dial giving one step per megacycle, with auxiliary dial with lead screw splitting each mc of the range into 10 points

In practice we have the difficulty of making 10-mil spacers, but even when they were exact the tuning curve had a random variation of a channel or so. An adjustable spacer system was then devised so that each spacer can be aligned by frequency to an exact mc point. The spacer finally developed for this experimental model is shown at the center of Fig. 3, and in action in Fig. 5.

The cam body is some stable alloy (such as aluminum, copper, silicon) die cast in the form of a flat-faced 24-point axial cam having a 0.120 in. hole in the center of each face. Then .2% chrome micro-finished balls (diameter of 0.125 in.) are inserted in the holes, using a tool which forced the balls in and swedged around them at a pressure of 500 lb. per ball. After swedging, the balls are of a relative height determined by the accuracy of the tool (which is about a quarter thousandth) so each ball is higher than its neighbor by 10 mils plus or minus two tenths, even though the absolute thickness of the cam body may vary ±4 mils. As indicated in Fig. 5, on the back of the cam, opposite each ball, there is a cast channel with a two-degree angle at the bottom. These channels form the frustrum of a truncated pyramid. Held by a spring in each channel is a hardened and microfinished block with an opposite 2° taper. By pushing this block "uphill," or inward radially, the thickness of the assembly is increased by about a mil, giving a very tightly controlled thickness adjustment.

Alignment Methods

This cam floats between the lead screw and the pushrod, as shown in Fig. 5. The nose of the lead screw is a hardened button lapped to a very large radius (about 4 in.) so it is just off flat. The pushrod end is given the radius of the ⅛th in. balls, so it has a very smooth and positive detent action. The pushrod is held in line by a bushing and is biased by a one-pound spring against the cam and lead screw nose. As shown in Fig. 4, the cam is gear-driven.

In aligning the set, a precision frequency standard giving all multiples of one mc at once is used. The rf portion is aligned in the middle of the band by loosening the five large flat-head screws. These are shown along the side of the head unit (Fig. 2). This allows

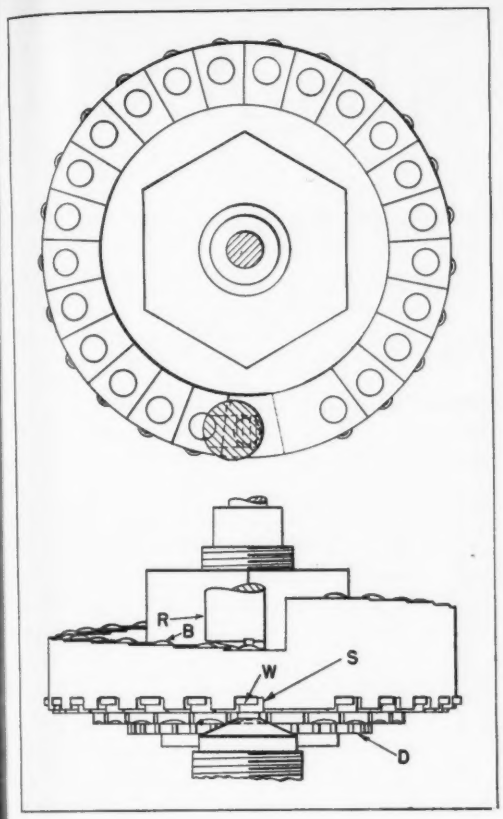


Fig. 5 — An adjustable spacer system permits each spacer to be aligned by frequency to an exact megacycle point

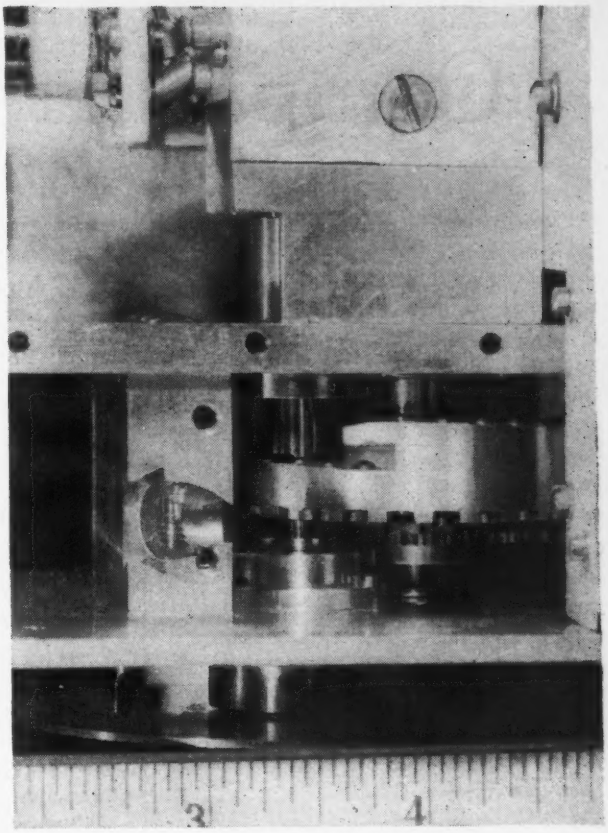


Fig. 6—The rotary cam that introduces axial displacement in twenty-four precisely adjusted steps. Wedge (W) sliding in tapered radial slots (S) advance push rods (B) the required amount to effect one megacycle frequency increments. Strong detent (D) insures location stability

the tuned circuit assemblies to be slipped to receive a modulated signal, the mixer tube plate current being clipped in the audio system and the oscillator turned off. When these screws are tightened, the needlelike points on the surface of the ceramic blocks actually puncture the metal clamps, so slippage is impossible. The circuit is then re-established as a superheterodyne and the oscillator tracked to the dial. A temporary bfo is then provided.

The first alignment point is near the high frequency end with the core retracted. As can best be seen in Fig. 5 (upper left) the oscillator tube socket has contacts that rest on the tank circuit contacts, and the tank can be slipped about 50 mils. This gives us a large take-up for mechanical tolerance of the assembly. This alignment point need not be too exact, as the cam thickness adjustment is used for final setting.

The next alignment is at the low frequency end, where the core is nearly inside the coil. The external iron slug is adjusted from a mean position to shift the slope of the tuning curve to agree with low frequency dial reading. It might be emphasized that a complex slope does not appear in this curve, such as is given by a capacitance padder. The curve is SLF with minor and random variations, usually not departing from absolute by more than a ten-thousandth at any point. This second alignment point again is only approximate, as it also is backed up by the thickness adjustment on the cam.

Independent Dial Points

The final alignment is by inserting the fine-adjustment device to push each block in toward the center of the cam, in each case bringing an exact mc signal to zero beat. This is not difficult since experience shows that the twenty-four points can be aligned in four minutes. The feature of this system is that each point is independent of the others, so if a slip is made on one the rest remain in alignment.

The mechanical parts of any precision device such as this must be worn in, so the dial is rotated by a motor about a hundred times before alignment. It should also be temperature cycled twice—at least up to 250° F. and allowed to cool to ambient or below.

A change in tubes can be accommodated by having the dial slip on the shaft. Practically any tube can be compensated for throughout the tuning range by slipping the dial 75 kc. About 125 kc will realign the system for a change from 1½v. tubes to 6.3 v. tubes.

By aligning the zero beat to within 100 cycles, the cam is actually adjusted to the required thickness to within one micro-inch. It consistently resets to that figure if previously worn-in sufficiently. This wear-in period actually cold-forges the pushrod to the average ball radius. The detail on the end of the pushrod allows wear of the shoulders of the radius groove without changing the essential distance dimension. Detail also must be incorporated in the cam to lift the nose of the lead screw off the blocks when sliding from one to the other.

With six volt acorn tubes the performance was found to be as follows: Sensitivity rf grid, noise times 2 = one microvolt; step-up from 72-ohm line = 3; rf stage gain = 3. This was limited by operating the tubes at 100 volts with 2 milliamps on plate so as to retain long life; mixer gain = 4; grid injection voltage 2 v. average, to minimize load on oscillator.

(*Continued on page* 106)

Comparing FM with AM

For military operations, FM has capabilities for greater range and noise suppression, is less critical as to tuning, less susceptible to jamming

THIS report, based on work done at Central Communications Research, Cruft Laboratory, Harvard University, indicates that narrow-band FM has certain definite advantages over AM for airborne VHF communications purposes. The work was done at the request of the Army Air Forces.

● In comparing amplitude and frequency modulation for military voice communication systems, it must be kept in mind that high fidelity and extreme quietness of output are of minor importance. Hence comparisons cannot be based upon broadcast technics. An audio-frequency range of approximately 300-3000 cycles per second is adequate (although there is some tendency to increase the upper limit) and a considerable amount of noise can be tolerated provided the message can be read through it.

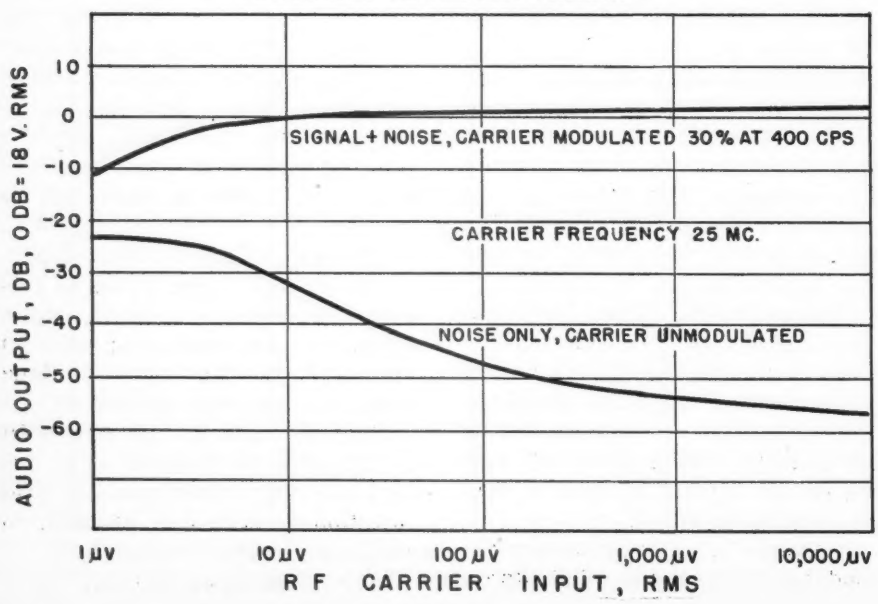
In the presence of random noise, a signal-to-noise ratio of perhaps two to one would be the minimum yielding usable communication; and in the presence of impulse interference the pulses could have a higher peak value than the noise, provided their strength is not such as instantaneously to overload the ear and provided their length is short enough so as not to mask the desired signal.

In the presence of random noise only, it is certain that when the carrier is large compared to the noise, the FM receiver has a quieter output than the AM receiver. The minimum rms carrier strength at which the improvement is obtained commonly is termed the "threshold" level and is approximately twice the rms value of the random noise. For carrier levels below the threshold, the theory available is rather meager, but certain conclusions can be drawn based upon available theory and test data.

The threshold carrier level for a narrow-band system is lower than that for a wide-band system. At carrier levels below the threshold of the narrow-band system, the audio output of the narrow-band system is quieter than that of the wide-band system. Hence, for maximum range or distance, the narrow-band system is to be preferred.

The next question is whether the FM system is better or worse than AM at carrier levels below the threshold level. There is much evidence to indicate that the performance of the FM system is superior. In results published by R. T. Weir[1] in 1939, the performance of AM was compared with that of FM by using the same receiver for both systems, in which a limiter and discriminator were used to detect FM and a diode linear detector was used to detect AM. Hence at the same carrier level, the carrier-to-noise ratio was identical for FM and AM. The IF selectivity curve was 220 kc wide at 6 db down, and the frequency swing used was ±80 kc. The FM system was found superior to the AM system at all carrier levels. M. G. Crosby has made tests comparing the readability of amplitude and frequency-modulated signals.[2,3]

Fig. 1—Signal-plus-noise ratio of amplitude modulation receiver, as measured on a Ballantine vacuum tube voltmeter



[1] I. R. Weir, "Field Tests of Frequency and Amplitude Modulation with Ultrahigh-frequency Wave," G. E. Rev., 42, 188, May 1939.

[2] M. G. Crosby, "Band Width and Readability in Frequency Modulation," R.C.A. Rev. 5, 363, January 1941.

[3] M. G. Crosby, Readability of FM, AM and Telegraph Systems, N.D.R.C. Division 15 Report 895-4, 24 August 1945, Contract OEMsr-895, Project RP-131, Radio Corporation of America.

for Aircraft Communications

In Fig. 5 of reference 3, an FM system using a 6-kc deviation is shown to be superior to a 20-kc deviation system at low signal levels, and in Fig. 6 of the same reference, the 6-kc deviation system is superior to AM at all signal levels. In the NDRC report of reference 4, test results are given in which a ±20 kc deviation FM system yielded a signal of minimum readability at a signal level 6 db below that required by AM. The corresponding figure for an FM system using ±6 kc deviation is 9 db.

Testing Methods

Experiments made in this laboratory confirm the results of R. T. Weir, Two Signal Corps type BC-603 receivers[1] were used. These were identical in construction and bore consecutive serial numbers. Receiver BC-603 serial No. 3719 was used as obtained except for minor changes and the substitution of an ac power supply for the dynamotor. Receiver BC-603 serial No. 3720 was modified for AM by operating all IF amplifier tubes at normal supply voltages and using the grid of the limiter tube as a linear diode detector, supplying audio output and AVC voltage.

The IF response curves of the two receivers were practically identical with a band width of approximately 85 kc at 6 db down. The signal generators used were the Signal Corps type I-208 for FM and the General Radio type 805-B for AM. Figs. 1 and 2 show the signal plus noise-to-noise ratio of these receivers measured at a carrier frequency of 25 mc, the noise being random noise arising within the receivers. The modulation frequency was 400 cycles per second, with amplitude modulation adjusted to 30% and the frequency modulation adjusted to a deviation of ±12 kc. The performance of FM is consistently better. At an rf input of 1 μv, the signal plus noise-to-noise ratio is 13 db for AM and 37 db for FM.

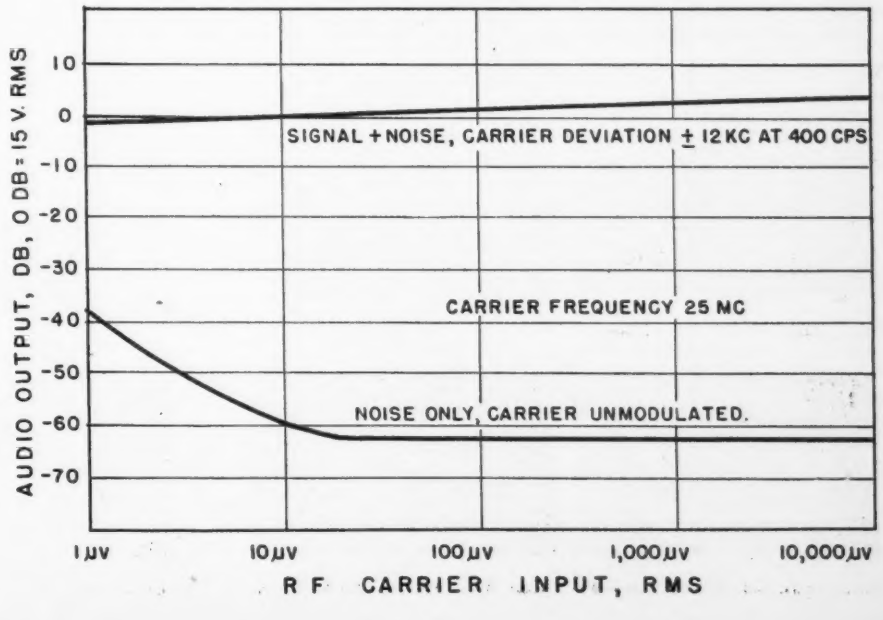
When FM signal generators are not available, it is common practice to use an unmodulated signal from an AM signal generator, in a test known as the "quieting test." The random AF output noise is measured as a function of the rf carrier signal strength. The carrier strength required to suppress the random AF noise to an arbitrary figure, say 20 db, below the noise at no rf signal input, is used to indicate the sensitivity of the set. For the FM receiver of this test, the signal required to produce "20 db of quieting" is 1.1 μv.

Comparison of the two receivers is facilitated by the oscillograms of Fig. 3, made under conditions of random set noise only, amplitude modulation 30%, and frequency swing ±12 kc, both at 400 cycles per second.[5] With no signal input, the noise output of the FM set is greater. At 0.5 μv signal, the AM receiver has a weak and noisy output, whereas the FM receiver has an output almost equal to the maximum, and is fairly "clean." At a signal of 1.0 μv, the noise is still very evident in the AM receiver and the output is not up to full strength, whereas the FM receiver has a full-strength, clean output. For signals above 5.0 μv, the performance of the two receivers is practically the same. The weak-signal performance of the FM receiver is definitely better.

Against pulse interference, an AM receiver has no protection except that which may be added in the form of clippers or limiters. An FM receiver can suppress pulses even without its IF limiter when there is no carrier and when the pulses occur at the peaks of the rf cycle. At other times the IF limiter suppresses the effects of AM caused by the pulses. The ability of FM to suppress ignition noise has been the main factor in the adoption of FM by the Signal Corps for vehicular communication. Only by using noise limiters can the performance of AM be made comparable to that of FM in the presence of pulse interference.

The photographs of Figs. 4 and 5 were taken to show the effects of rf carrier strength and receiver tuning on the output resulting from pulse interference in the absence of modulation. In the AM receiver, Fig. 4, the performances were iden-

Fig. 2—Signal-plus-noise to noise ratio of frequency modulation receiver, as measured on a Ballantine vacuum tube voltmeter



[1] Part of SCR 508 frequency modulation transmitter-receiver equipment covering the frequency range 20.0-27.9 megacycles.

[5] The photographs were made with 1/20 second exposure, so that each photograph shows 10 traces superimposed.

tical with the carrier on tune and with the carrier detuned 12 kc. The output due to the pulses decreased as the rf carrier was increased due to the reduction of amplification caused by the AVC circuit.

In the FM receiver, Fig. 5, the pulses were very well suppressed at all signal levels when the carrier was tuned to the center of the pass band of the receiver. With the carrier detuned 12 kc,[6] the pulses were not suppressed so well, but the degree of suppression seems fairly independent of signal level for the range of carrier strengths shown. The pulse output from the FM receiver is less than that of the AM receiver even when the FM receiver is detuned by an amount corresponding approximately to 30% modulation (i.e., 12 kc).

The pulse suppression in Figs. 5d and e is not quite as good as that in Fig. 5c. Before making the oscillograms, the receiver was tuned to yield maximum output when the input signal was a 1 μv carrier modulated at 400 cps, (30% for AM, and $\pm$12 kc for FM.) At signal levels other than this, the input impedances of the tubes change, causing a slight mistuning, resulting in slightly more pulse output from the FM receiver.

In Fig. 6 the performances of the AM and FM receivers are compared, with the carrier detuned 12 kc, with pulse interference, and with the carriers modulated (30% for AM, and $\pm$12 kc for FM).

The pulses occuring at the zeros of the modulation cycle are not suppressed in Fig. 6, since the carrier is not at the center of the rf pass band due to the detuning of

[6]Due to asymmetry of the electrical characteristics of the receiver, detuning the carrier 12 kc below 25 mc produced better results (i.e., less pulse output) from the FM receiver than detuning the carrier 12 kc above 25 mc. The oscillograms shown are for the carrier detuned 12 kc above 25 mc for both receivers.

Fig. 3—Comparison of outputs from AM and FM receivers at signal inputs indicated, in presence of random set noise

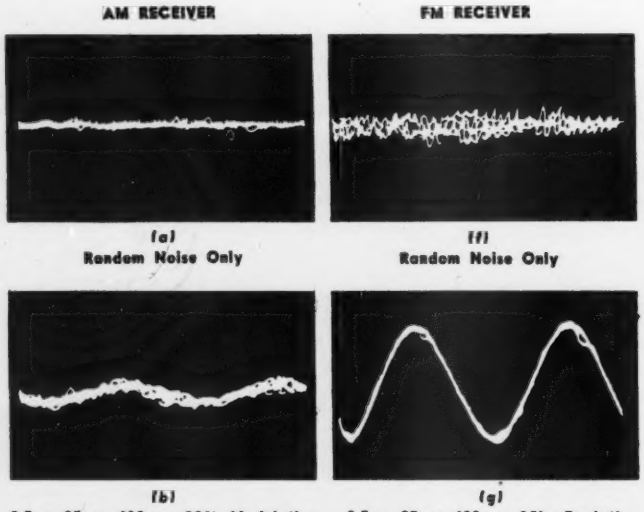
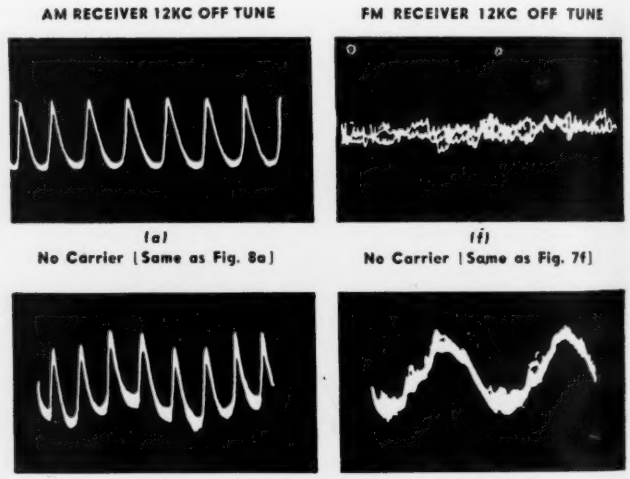


Fig. 6—Comparison of outputs from AM and FM receivers at signal inputs indicated, both receivers 12 kc off tune, in presence of random set noise and 1600 cps pulses



the carrier. The pulses at one peak of the modulation cycle are suppressed to a degree, but the pulses occuring at the other peak are not so well suppressed. However, the performance of the FM receiver when detuned 12 kc seems better than that of the AM receiver at all signal levels.

Effect of Jamming

With respect to jamming and interference, the behavior of FM is quite different from that of AM. The available data for FM is for the condition where the desired signal is strong enough to operate the limiter. FM exhibits an effect called the "capture effect" described by Weir.[7] If two carriers are present at the limiter, and one is at least twice as strong as the other, the stronger signal "takes over" and the weaker does not appear. The suppression of the weaker signal is quite complete, and it cannot be discerned in the background as with AM. A strong amplitude-modulated carrier can suppress the modulation on a much weaker carrier having a different carrier frequency,[8] causing the apparent selectivity to be higher than the actual, but this effect is not comparable to the capture effect in FM.

With regard to jamming by a continuous-wave (unmodulated) signal, the situation at frequencies above about 75 mc is somewhat different from that below 75 mc. Above 75 mc, self-excited oscillators have a random frequency shift which imparts to the wave a property similar to that of a carrier frequency-modulated by noise. This prevents a continuous-wave signal from being as "pure" above 75 mc as it is below, so that the interference produced becomes similar to that produced by a wave frequency-modulated by noise. However, if the continuous wave arises from a transmitter which is crystal controlled, the random frequency shift is removed and the interference is the same in nature as that produced by continuous waves from self-excited oscillators at the lower frequencies.

In the range 100-150 mc, CW interference is less effective than is a carrier frequency-modulated by noise. The ideal frequency deviation for the noise-modulated jamming signal is from ±2 to ±10 kc.

Antenna towers atop Cruft Laboratory at Harvard University, Cambridge, Mass., where the work upon which this report is based was done for Army Air Forces

In general there is no marked superiority of either AM or FM as to resistance to jamming. Both can be jammed. The deterioration of the desired signal is more gradual in AM sets than in FM sets. FM is slightly superior in that the desired signal remains clear until the undesired interference "takes over" the limiter. Then the degree of jamming rises sharply. Both AM and FM sets are thoroughly jammed when the jamming signal is from 6 to 10 db higher than the desired signal.

In one respect the AM receivers are superior to the FM receivers, namely, the AM receivers are less vulnerable to CW interference occuring when the beat or difference frequency is inaudible through the audio system of the receiver. Such CW interference can take over the limiter in an FM set when it is approximately twice the strength of the desired signal whereas it will not take over an AM set unless it is so strong as to decrease the sensitivity of the set by building up a large AVC voltage.

Pulse Interference

Against interference of a pulse type, the FM receivers are in general better than the AM receivers equipped with noise clippers. It was Ports' opinion that even the best clipper available would not render an AM receiver as quiet as an FM receiver in the presence of pulse interference.

Communication by FM is more susceptible to distortion due to multi-path transmission when the differences in the time of transmission over the paths is of the order of the period of the modulation cycle. If the delay of one signal due to the path-length difference is of the order of the period of one rf cycle, the effect of the interference is to alter the intensity of the modulated carrier exactly the same in FM as in AM and not to distort the signal.[9,10,11,12,13] When the delay is an appreciable fraction of one modulation cycle, the received signals are appreciably different in frequency, and the resulting beat note causes sharp peaks to appear in the output.

Time delays of this magnitude are not to be expected at very high frequencies where propagation is quasi-optical, and no such effects have been observed in flight tests conducted for Wright Field by Bendix Radio, Division of Bendix Aviation Corp., Baltimore, Md. Where the time delay is of the order of one rf cycle, the carrier strength changes. An effect such as this has been observed in railroad communication.[14] Reflections from buildings and other objects caused the strength of the carrier to "flutter." (A similar effect might be observed at very short wavelengths in formation flights of aircraft.) It was found in reference 14 that the limiter of the FM receiver was more effective than the AVC circuit of the AM receiver in removing the effect of "flutter" due to rapid variation in signal strength while the train was in motion.

Practically all communication re-

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[7] I. R. Weir, loc. cit.

[8] E. V. Appleton and D. Bookariawalla, "The Mutual Interference of Wireless Signals in Simultaneous Detection." Exp. Wireless and Wireless Eng., 9, 136, March 1932.

[9] T. L. Eckersley, "Frequency Modulation and Distortion," Exp. Wireless and Wireless Eng. 7, 482, September 1930.

[10] M. G. Crosby, "Frequency Modulation Propagation Characteristics," Proc. I.R.E., 24, 898, June 1936.

[11] M. G. Crosby, "Observation of Frequency-Modulation Propagation on 26 Megacycles," Proc. I.R.E., 29, 398, July 1941.

[12] H. A. Wheeler, "Common-Channel Interference Between Two Frequency-Modulated Signals," Proc. I.R.E., 30, 34, January 1942.

[13] N. M. Blachman, Internal Memorandum, 10 September 1945.

[14] E. Dahl, "Rock Island Railroad Tests," Electronics, 18, 96, May 1945.

ceivers are equipped with a "squelch" circuit, which renders the audio-frequency amplifier inoperative in the absence of a carrier. In the AM receiver, the "squelch" is "opened," i.e., the af system is placed in operating condition, by the AVC voltage developed by the detector. If the squelch is set to open on a very weak carrier, peaks of noise often cause false operation of the squelch circuit due to the momentary existence of appreciable AVC voltage.

In the FM receiver, the presence of a carrier reduces considerably the random af noise output of the set. This makes it possible to balance a voltage caused by the presence of the carrier against a voltage caused by the af noise, so that a very weak carrier can open the squelch but a noise crash cannot. It is possible to secure reliable operation of the squelch circuit by carriers so weak that the modulation cannot be understood. This advantage of FM is somewhat counterbalanced by the fact that the presence of very weak interference causes false operation of the squelch.

There has been some indication that in the 30-40 mc emergency communication band, there is more trouble due to adjacent channel interference with FM than with AM.[15] This may be due to the higher sensitivity of FM receivers and to the fact that the squelch can be set to operate on very weak signals. Means have been developed to eliminate false operation of the squelch by use of tone modulation whose frequency may be set as to secure selective action even on the same frequency channel.[16]

(*Continued on page* 110)

[15]Eastern State Police Radio League Report to the F.C.C. See FM Magazine, 5, 4, September 1945.

[16]G. C. Brown, "Selective Calling Communications," FM Magazine, 5, 41, October 1945.

Fig. 4—Effect of tuning on output of AM receiver at signal inputs indicated, with random noise and 1600 cps pulses

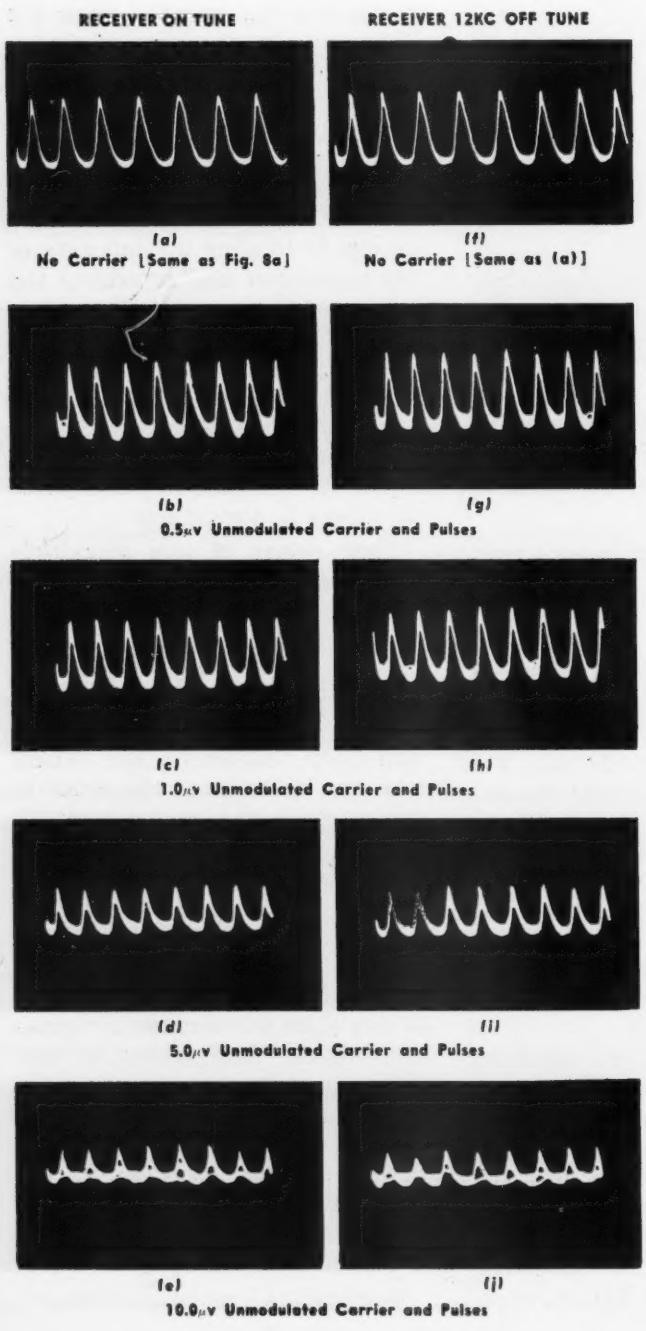
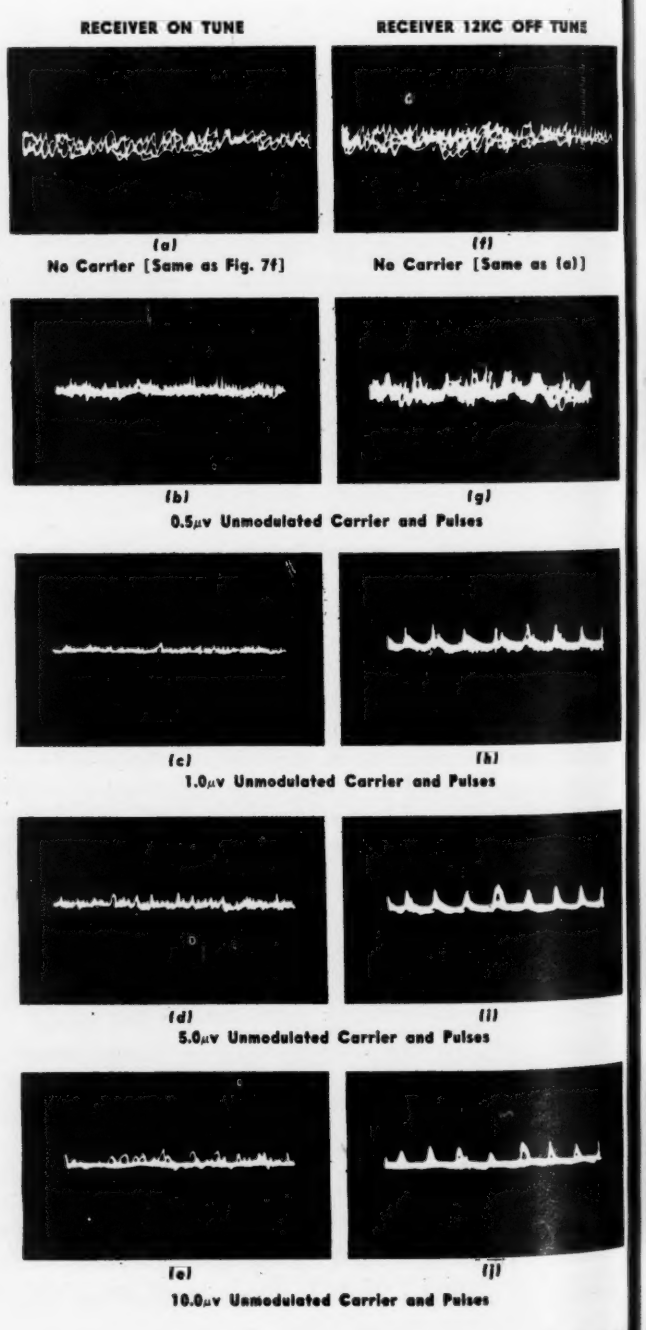


Fig. 5—Effect of tuning on output of FM receiver at signal inputs indicated, with random noise and 1600 cps pulses



Pulse Width Measuring Method

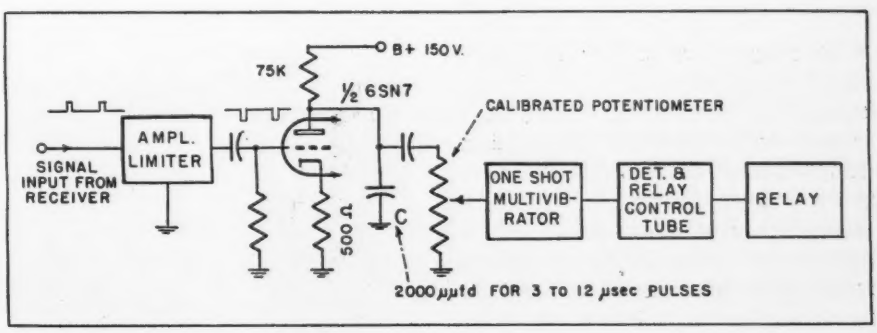
Accuracy to within one-quarter microsecond for widths from 3 to 12 microseconds attainable independent of repetition frequency

• To aid in automatically distinguishing between types of enemy radar signals, such as "early warning" and "gun-laying" radar, a pulse width measuring instrument was developed, which may have possible applications in other fields.

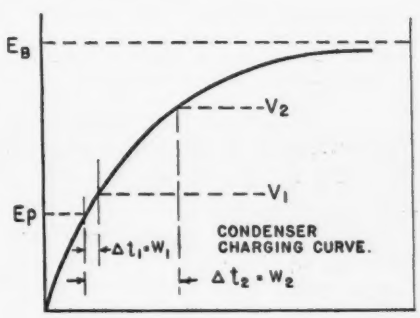
The first stage of the circuit consists of a voltage amplifier-limiter, which serves to widen the range over which the pulse width measuring circuit will function independently of input signal voltage. From the limiter, the signal, which is inverted at this point, is fed into a capacitance charging stage, shown schematically. In this stage the triode is normally biased so that plate current flows through the tube. At such time the capacitor C is charged to a voltage E_p, somewhat less than the supply voltage E_b because of the voltage drop in plate resistor R. When a pulse occurs, the grid is driven negative to cut-off, the voltage drop in R due to plate current vanishes, and C will immediately start charging to the supply voltage E_b.

Referring to the curve it will be seen that if C is large enough so that it is only partially charged by the pulse, the amount of charge will depend upon the pulse width. This presents at the output a voltage pulse the amplitude of which is nearly a linear function of pulse width. Actually, the charging curve is an exponential function, but when operating over a small portion of the lower part of the curve, this can be considered nearly linear.

It should be noted that when C is small enough so that it comes practically to E_p value between



First stage of the circuit, and schematic of one-shot multivibrator trigger



Amount of capacitor charge is essentially linear with pulse width

pulses, discharging its excess voltage through the tube and through the plate resistor, it therefore is not capable of adding successive pulses of the ordinary radar signal repetition frequencies. This means that operation will be independent of pulse repetition frequency.

A one-shot multivibrator, which is very sensitive to trigger voltage amplitude, is made use of to transform the capacitor voltage pulse into a voltage suitable for operation of a relay control tube. When tripped, such a multivibrator goes through one cycle of operation, presenting at its output a single square wave for each time it is triggered. In this application, the multivibrator is triggered at the received radar pulse repetition frequency, so its period is adjusted to be less than that of the highest radar pulse repetition frequency. Any given radar pulse width can be selected by the adjustment of the calibrated input potentiometer. The output of the multivibrator circuit is detected in a gridleak detector which serves to rectify the multivibrator output when it is being triggered, so that a suitable dc voltage is furnished for operation of the relay regardless of the repetition frequency.

This circuit can be used either to measure the pulse width of an input signal by adjustment of the calibrated potentiometer to the point where the relay operates, or it can be used as a "go-no go" indicator by presetting the potentiometer at the desired value of width measurement.

With good voltage regulation accuracy was found to be attainable to within about a quarter of a microsecond for widths of from 3 to 12 microseconds, and for wide ranges of signal input voltage and pulse repetition frequency.

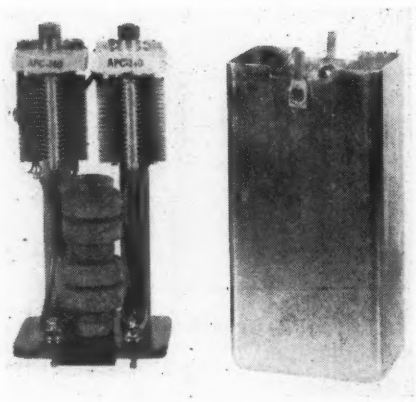
Standard Frequency Generator

By S. J. HAEFNER and R. H. SMITH
U.S. Navy Underwater Sound Labs., New London, Conn.

Pushbutton operation permits selection of any frequency between 40 kc and 1000 kc through use of harmonic generators and external 100 kc crystal

• To supply a need for a standard signal generator for crystal research the Underwater Sound Laboratory of the Navy at New London designed and built an instrument incorporating a number of interesting features. This generator is pushbutton operated and supplies frequencies from 40 kc to 1,000 kc in steps of 40 kc. It has no internal standard of frequency, being designed to use an external standard source of 100 kc. In addition it is to be used with an interpolation oscillator capable of furnishing any frequency between 10 kc and 50 kc. The combination then will supply any desired frequency between 40 kc and 1,000 kc.

The harmonic distortion from this instrument is not greater than 1%, but the accuracy of the output frequencies is dependent solely on the accuracy of the external 100 kc source.

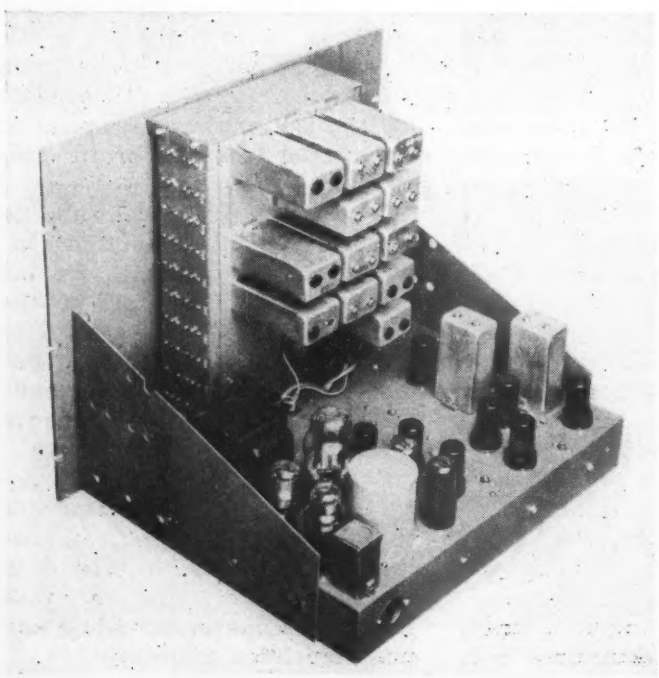


One of the individual filters shown below as it is mounted

As shown in the block functional diagram of the signal generator, a tuned 100-kc buffer amplifier is followed by three harmonic generators and associated tuned circuits, two subharmonic frequency dividers (800 kc to 160 kc and 600 kc to 120 kc), a converter, a volume control, a phase inverter, and a push-pull power amplifier. A pushbutton switching arrangement provides easy selection of the desired output frequency.

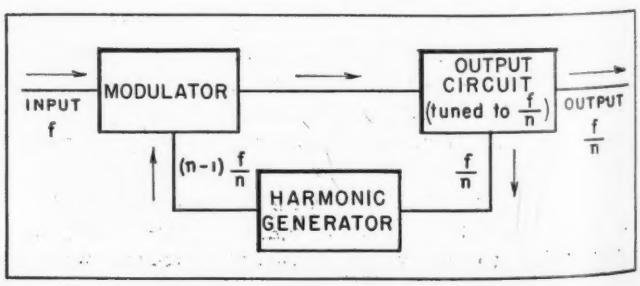
The 200-kc, 400-kc, 600-kc, 800-kc, and 1000-kc filter sets are shown on the block diagram as often as used. Actually, only one tuned filter of each of these frequencies appears on the chassis and the pushbutton switches switch these tuned filters into or out of the circuit as required. Each of these filters is made up of two simple tuned circuits in cascade and is mounted in a shield can.

The filter set following the converter, shown at the right of Fig. 1, consists of seven transformers with tuned primaries and tuned secondaries. The switching arrangement permits connection of a suitable pair of tuning condensers, one across the primary and one across the secondary, so that 18 tuned circuits at frequencies of 40, 80, 240, 280, 320, 360, 440, 480, 520, 560, 640, 680, 720, 760, 840, 880, 920, and 960 kc are available.



Left, angle view of the signal generator showing general arrangement of the filter elements

Below, block diagram of a subharmonic generator or frequency divider



The 120-kc and 160-kc frequencies are obtained from a division of the 6th and 8th harmonics respectively of the 100-kc standard, 120 kc being 1/5 the 6th harmonic and 160 kc being 1/5 the 8th harmonic. The outputs of the 160-kc and 120-kc frequency divider circuits have tuned filters. These are shown blocked in as the 160-kc filter and 120-kc filter respectively on the upper left-hand portion of Fig. 1. These frequencies are passed to the phase inverter and then to the power amplifier when desired at the output.

The frequencies 200 kc, 400 kc, 600 kc, 800 kc, and 1000 kc are the 2nd, 4th, 6th, 8th, and 10th harmonics of the impressed 100-kc standard frequency. These harmonics are filtered and passed to the phase inverter and then to the push-pull power amplifier when desired at the output.

Other output frequencies are obtained by conversion in the signal generator. For example, 40 kc is obtained by taking the difference between 200 kc and 160 kc. This is clearly shown in Fig. 1, the output filter automatically selecting the desired sum or difference frequency.

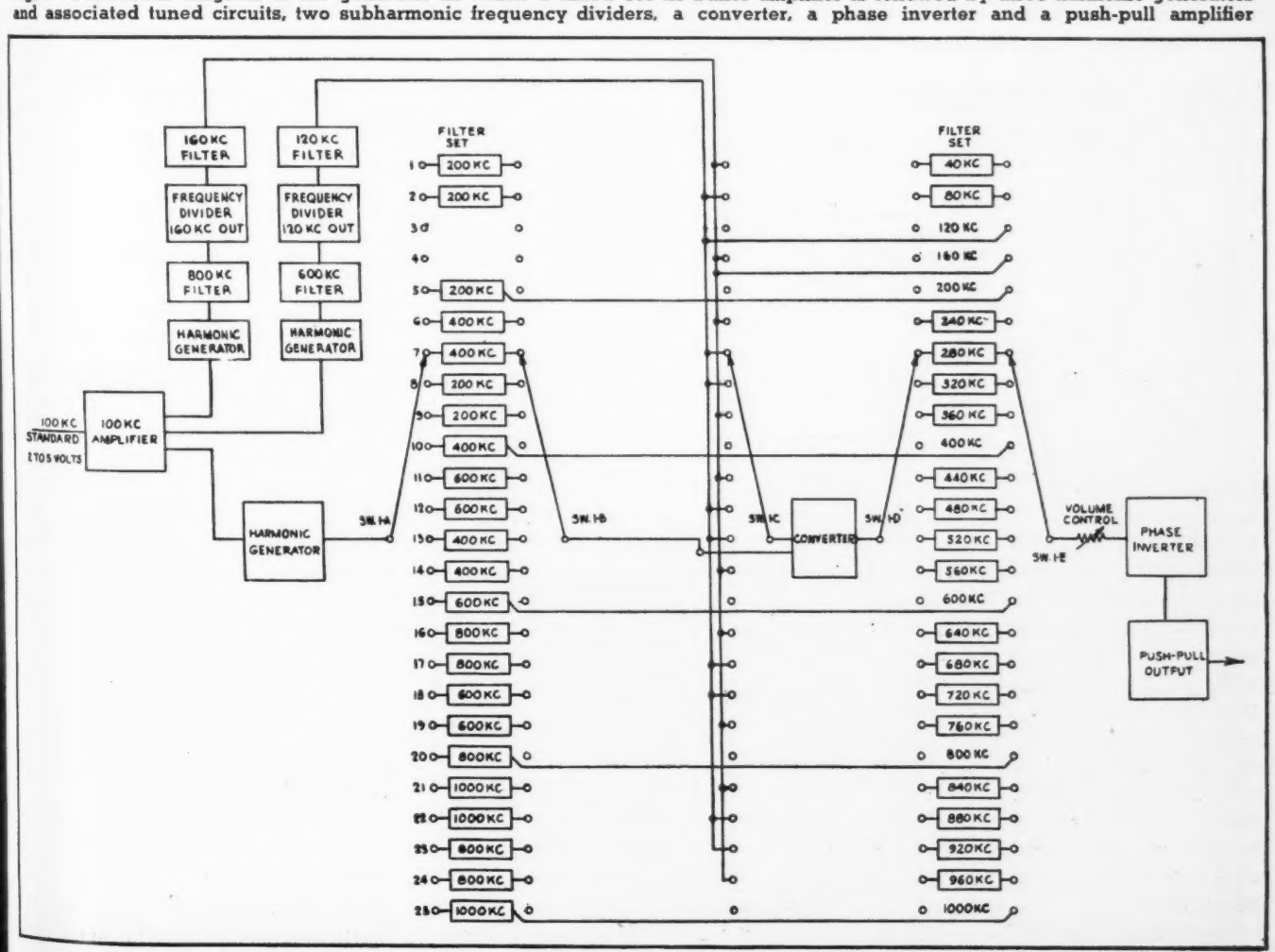
The frequency divider circuit used has been adapted from the one described in F. R. Stansel's article "A New Frequency Divider for Obtaining Reference Frequencies," *Bell Laboratories Record*, Vol. XXI, No. 4, Dec. 1942, pp. 97-99. A block diagram of a subharmonic generator or frequency divider, is illustrated and consists essentially of a modulator, an output circuit tuned to the submultiple frequency to be produced, and an harmonic generator. Once this circuit is in operation, its action is easy to understand. Assume, for example, that the input frequency is 800 kc, and that the output frequency is 160 kc. Part of the output is fed back to the harmonic generator, where its fourth harmonic, 640 kc, will be selected by a tuned circuit.

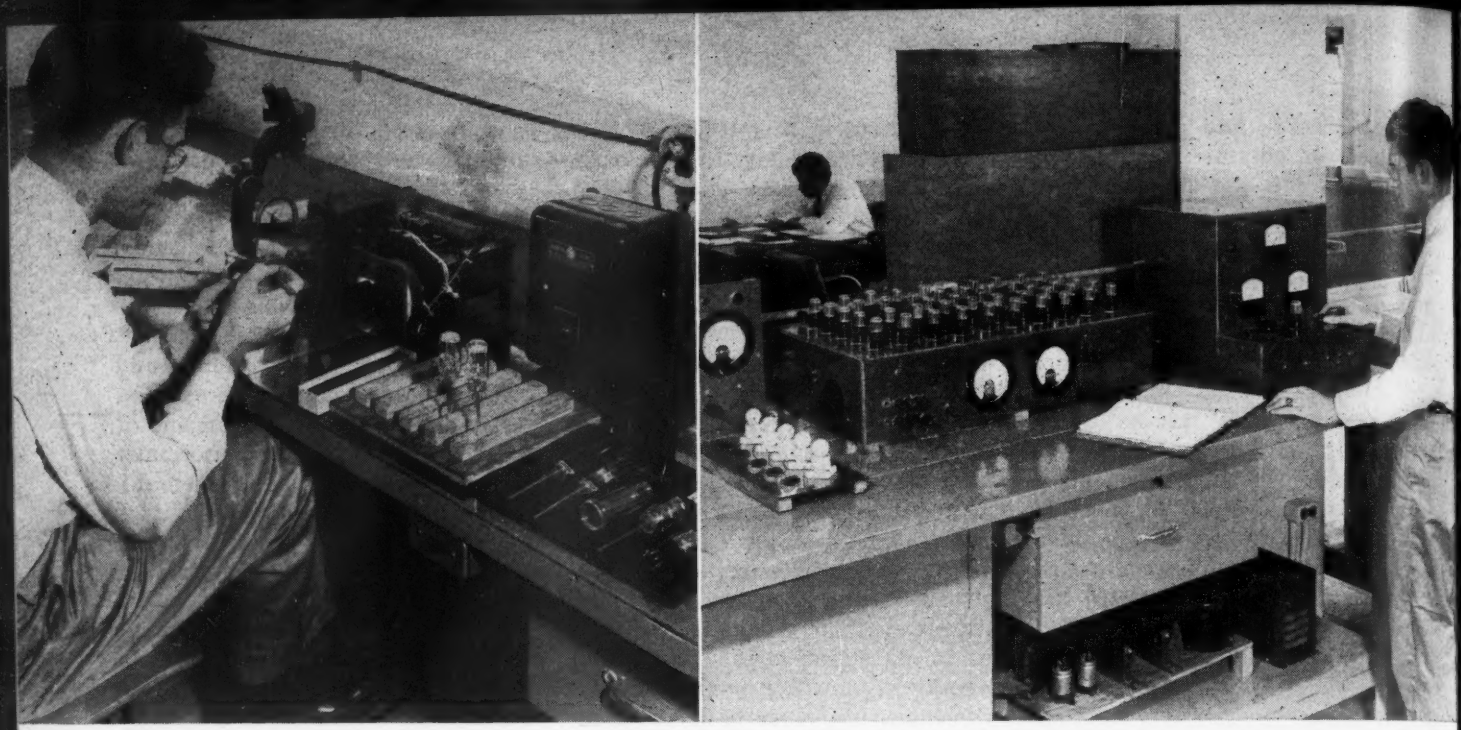
This 640-kc frequency and the 800-kc input will result in a difference frequency of 160 kc in the output of the modulator, and in a number of other frequencies as well. The 160-kc frequency, however, which is the ouput frequency desired, is selected by the tuned circuit.

To start the oscillators, some 160-kc component must be present in the circuit. It has been found possible to depend for the starting pulse on the 160-kc component of the transient voltage normally present in the circuit. In general, when the nth submultiple frequency is desired, the harmonic generator is tuned to the (n-1)th harmonic.

Unlike the multivibrator, the regenerative frequency divider cannot operate without an input frequency. Should the input frequency fail, the output drops to zero, and thus off-frequency operation cannot occur. In addition, the output voltage of the generator is a relatively pure sine wave; additional "clean up" filters are not required, as they are with the multivibrator when a sine wave is desired.

Fig. 1—Functional diagram of the generator in which a tuned 100 kc buffer amplifier is followed by three harmonic generators and associated tuned circuits, two subharmonic frequency dividers, a converter, a phase inverter and a push-pull amplifier





Two steps in the production of cathode materials: Left, assembly of diode tube for testing purposes; right, initial stages of electrical characteristic seasoning, testing and life testing

Cathode Sleeve Fabrication

High precision technics in production of various tube parts, plus newly developed testing methods that insure uniformity of characteristics

• While the tube requirements of radio users have been spectacular in quantities, now nearing 200 million a year, actually the most important contributions by the tube industry have been the improvements in the operating characteristics of the tubes themselves. Better tubes mean not only better but cheaper receiving sets. A feature less commonly considered is that uniformity is a factor that is rated of higher importance than are high amplification possibilities. Obtaining both characteristics in a modern tube has called for much specialized research on each component in the assembly, and the development of unusual technics in their fabrication.

Toward this end the best features of electronic regulation, control and measurement have been utilized in tube manufacture and assembly. This is exemplified by the production methods used in preparing the small nickel tubing used as thermionic cathodes. At the Superior Tube Co., Norristown, Pa., a new plant has been put in operation to specialize on this one item.

Obtaining Uniformity

Uniformity of electrical characteristics is dependent upon dimensional, metallurgical and chemical precision. In the drawing and fabrication of cathode tubing, it is necessary to obtain dimensional accuracy which is far closer than normal commercial tolerances, explains Thomas H. Briggs, electronic engineer for Superior. For example, tubing diameter and wall thickness may be held within ±0.00025 in. and lengths are cut to within ±0.005 in. Even these figures are bettered in certain production runs, especially for radio tubes where cathode-to-grid clearances may be less than 0.005 in. and where a snug fit of the cathode into the mica spacer helps to reduce noise levels. This is accomplished by tungsten carbide and diamond dies and other production facilities handled by skilled operators.

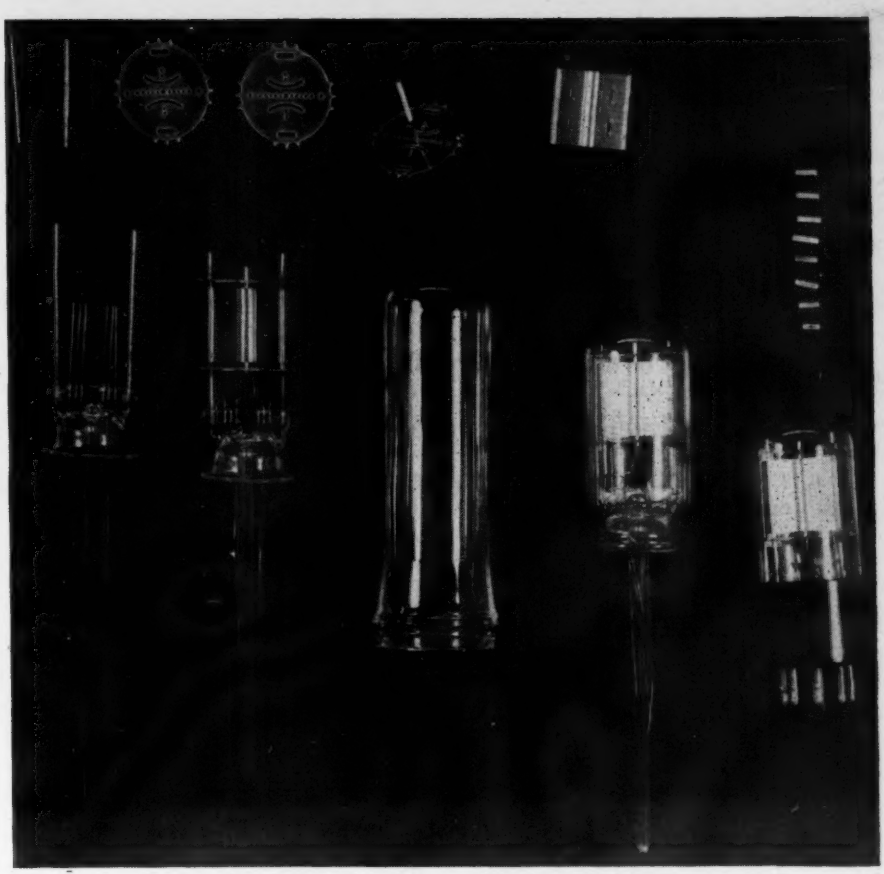
The production of quality tubing is accomplished by successive cold drawing operations starting with large size billets. As many as sixteen separate passes through dies

are necessary to obtain the desired reduction in diameter and wall thickness. After almost every drawing operation there is a cleaning and a bright annealing so that the metal may be softened for further working. All previous lubricants must be removed to avoid burning them into the surface, harmful to emission. The speed of the draw benches is accurately controlled for uniform temper and size by Thymotrol drives since the motor load varies widely and rapidly. Manual transfer of the heavy large size tubing is extremely difficult. Consequently, a roller conveyor with elevators and kick-offs has been installed. The action of this conveyor is electronically controlled.

Precision Standards

Some tubing is atomic hydrogen welded after nickel ribbon is cylindrically formed. Speed of ribbon travel and electric arc conditions are maintained at critical settings to insure uniform welding quality, by electronic controls. Ever widening use of electronic equipment in the mill has been noted. Each such application has demonstrated its value and is more than paying its way. A new program is extending such automatic operation to a battery of other machines, so that cathodes for some thirty-seven different tube styles will be produced. An electronics laboratory has also been established to do basic research on emission and to study problems of cathode tubing production in the light of meeting the ever increasing requirements of precision. A standard form of diode tube is in constant production solely to check the emissivity of various lots of cathode material.

All of the equipment of a small radio tube factory is to be found in this laboratory. Here the parts are processed, cathodes sprayed, mounts welded together, sealed and exhausted, after which numerous electrical tests and life tests are run. The spot welder employs a thyratron timing control. The high frequency furnace, ionization gauge, and Pirani gauge represent other applications of electronic control in production of electronic tubes. The principal object of the work is the development and production of better tube materials.



Parts and assembly stages of diode tube used for testing cathode materials

Part of the exhaust equipment used in the process of laboratory testing

Experimental 1000-Line TV

Abstracted from the French*: By JOSEPHA E. ZENTNER, Ph.D., Digest Editor, Tele-Tech

To prove their hypothesis, French engineers design and construct an experimental transmitter and receiver operating at a frequency of 145 mc

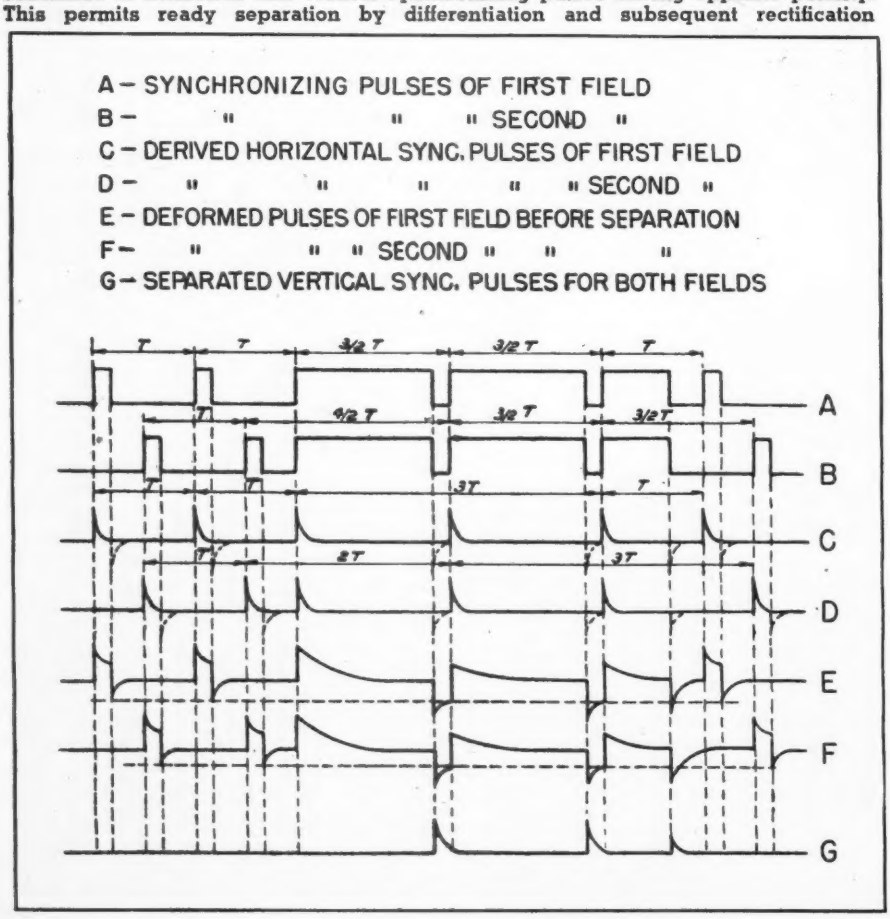
• An experimental television station was built in Montrouge, France, primarily to investigate the minimum number of lines required to completely satisfy the eye of an observer. Optimum viewing conditions obtain if the finest picture detail is of the size of the smallest unit discernible by the eye from the closest distance permitting a view of the complete picture area. Further improvement of picture detail will not be appreciated by the observer.

We may simultaneously view a picture extending 40° (or 2400 minutes) in a horizontal direction, while we can discern a detail exceeding two minutes. The ratio of the finest detail to the width of the picture is then equal to 1200. Assuming an aspect ratio of 4 : 3, the minimum number of lines required is equal to $1200 \times \frac{3}{4} = 900$. Thus a 1000-line picture appeared to meet all requirements.

To prove this hypothesis, experiments were carried out where the lines per field varied between 441 and 1575 and the frames contained either non-interlaced, or two or three interlaced fields, as desired. The experimental station incorporated a time base with a four-stage frequency divider using relaxation oscillators, which permitted rapid changes of both the number of lines and the number of interlaced fields. The field repetition frequency was always 50 times per second and the average light intensity of the 25 x 30 cm screen was 75 lux (7 foot-candles).

A 1015-line, twice interlaced picture, repeated 25 times per second, was finally adopted as presenting the least technical difficulty while still meeting the requirements of an exacting viewer. A carrier frequency of 145 mc was selected. It is stated that the direct propagation characteristics of a 145-mc carrier are not considerably different from those of a 46-mc carrier currently used. Also sufficient power is available at 145 mc.

Schematic of horizontal and vertical synchronizing pulses having opposite polarity. This permits ready separation by differentiation and subsequent rectification



Circuit Details

The time constant of the transmitter output stage is given by twice the product of the value of the charging resistor times the shunt capacitance, indicating that the output resistor should be less than 1000 ohms for a 1015 line picture, even though the circuit capacitance does not exceed the centimeter range. Absorption modulation (Parker, *Proc. I.R.E.* 1938, p. 8) was used since it permits a wide

*M. Paul Mandel, Ingénieur aux Laboratories de la Cie des Compteurs, à Montrouge, France (Bull. de la Soc. Française des Electriciens (S. 6, Vol. V, No. 47).

frequency band and the time constant of the last stage is not limited by the modulation process.

To reduce the internal resistance of the modulating triodes, they were connected as diodes with regard to the carrier frequency by the insertion of suitable inductances in the grid circuit, internal capacitive coupling making plate and grid potentials identical for the carrier frequency. The maximum power, corresponding to white areas, was of the order of 200 watts, the modulation 70%, and the residual carrier was modulated with the synchronizing signal.

The low frequency amplifier was capable of delivering 300 volts peak-to-peak signal to the modulating triodes. It had uniform gain and negligible phase distortion over the transmission range. Constant impedance circuits presenting a constant, purely resistive impedance independent of frequency were used in this amplifier.

Special Features

Vestigial sideband transmission was used. The filter for shaping the transmission curve was connected to the line feeding the antenna. It was therefore necessary that the input impedance of the filter be constant and a pure resistance in the transmitted as well as in the suppressed frequency range. A coaxial line filter consisting of two k-type networks connected in parallel and terminated by the same resistance was used as filter.

No figure for the transmitted band-width was given. (By usual rules a band of 28 mc is indicated for a 1015 line structure.) The test receiver's sensitivity was of the order of 1 millivolt with the usual superheterodyne circuit. A parabolic reflector was used with the receiving antenna to reduce multipath interference.

Conventional synchronizing methods (where the interval separating the last horizontal synchronizing pulse from the vertical synchronizing pulse is less than the duration of half a line) were not taken into consideration because of the complexity of circuits designed for the separation of the two pulses only 25 microseconds apart. The synchronizing signal was therefore modified as in the figure to make this interval considerably longer than one-half line while maintaining identical repetition for each field.

It will be seen from lines A and B that the field and the line synchronizing pulses have opposite polarity and that the field synchronizing pulses are periodic for all interlaced fields. The figure further illustrates the differentiation of the pulses which results in a shift of the pulse levels permitting separation of horizontal and vertical synchronizing pulses by rectifiers. Inspection of lines C and D will reveal that, during the vertical deflection of the beam, the synchronization of the horizontal sweep generator is partially maintained. This assures undisturbed operation of the two sweep generators in the receiver and correct interlacing of the fields.

The construction of this receiver permitted the estimation that the price of a 1000-line receiver operating in the 100-mc range would not exceed the price of a 450-line receiver by more than 25%. Comparison of a directly projected film and a televised picture proved that the only difference between the two pictures was in contrast due to the characeristics of cathode-ray oscilloscopes.

Light-Beam Communication System

The concentrated-arc lamps described previously in ELECTRONIC INDUSTRIES (July, 1946, pg. 79), which produce a high intensity, narrow-beam .003 in. diameter light spot from an incandescent zirconium oxide cathode, have recently been adapted for use as a source of modulated radiation in light-beam communication systems operating in the spectral region between 3000 and 9000 amp. The small source produces an intense beam with a spread of less than one minute of arc with the 2-watt lamp with a possible range up to the horizon. Good modulation ability has been achieved at frequencies up to 10 kc, where the loss is about 12 db, using the infrared range.

An experimental light-beam telegraph circuit using concentrated-arc lamps has been in operation for some time in lower Manhattan between the main Western Union Office at 60 Hudson St. and a branch office in the New York Post Building at 65 Washington St., an airline distance of about ¾ mile. A teleprinter-telegraph circuit operating at 65 words per minute is carried by two light-beam systems, each operating in one direction. The transmitter, consisting of a 10-watt arc lamp produces a light beam focused by a parabolic mirror on an 18 in. Fresnel lens of the receiver. The ten-watt lamp, installed over 9 months ago, is still operating. The equipment has been operating since its installation unattended for 96.7% of the time of its actual use. Of the lost time only ½% was due to interruptions of the light beam caused by fog, snowstorms, and smoke.

Radio Observations in Meteor Shower

Interpretation of results of meteor observations by radio methods obtained during the Geminid shower, December 11 to 13, is in progress at the U. S. Bureau of Standards, Washington. It is clear from the observations that meteor trails are more effective in giving reflections if the trail is parallel to the electric vector in the radio wave. These conclusions were reached by study of reflections obtained in alternate 10-minute intervals with east-west and north-south polarization of the transmitting and receiving antennas. During the early part of the evening when the meteor radiant was in an azimuth forming an appreciable angle with both antennas, approximately equal counts of meteors were obtained with both antenna systems, but as the azimuth approached due east, significantly higher counts were obtained with the east-west antenna system.

The majority of the meteors observed by radio methods could be identified with visually observed meteors, although there were several occurrences of radio reflections unaccompanied by reports of visual observations. The visual counting rate was about three times as great as the rate for radio observations.

Field intensity meter in use, with operator adjusting loop for maximum rating

BC Field Intensity Measurements

Covering range from 200 to 7000 kc in four bands, instrument is suitable for stationary or mobile tests

• One of the first problems encountered by the broadcasting industry was the need to measure accurately the intensity of signals radiated from radio transmitters. As a requirement for the licensing and operation of broadcasting facilities, the Federal Communications Commission has laid down specific rules governing field intensity measurement, assuming the use of a measuring instrument of the best obtainable accuracy. Unfortunately, the development of instruments for such work has been slow and accuracy standards have not, until recently, been comparable with those maintained in other branches of the communications industry.

The design of a special superheterodyne receiver suitable for field strength measurements involves a number of refinements that may be of general interest to communications engineers. An instrument recently developed by the Federal Telephone & Radio Corp. for field strength measurements in the standard broadcast band is the Type 101C field intensity meter. This instrument has the distinction of being considered by the National Bureau of Standards to be of acceptable accuracy for radio field strength measurements. As a result the FCC has approved its use for field strength surveys and does not require calibration of individual instruments other than that supplied by the manufacturer with each instrument at the time of purchase.

The Type 101C is a portable, battery operated, four-band superheterodyne receiver having a measuring range of from 20 microvolts to 10 volts per meter in the following frequency bands: (A)—200-400 kc; (B)—530-1,600 kc; (C)—1,600-3,600 kc; (D)—3,600-7,000 kc.

Shielded Loops

Separate single-ended loop antennas are supplied for each range, the loops for ranges A and B being built into interchangeable covers for the instrument. This design tends to shield the antennas against unwanted pickup of stray fields, such as those due to body capacity. A chart of antenna coefficients is prepared for each instrument at fourteen points in the 530 to 1,600 kc band. Field strength (in microvolts/meter) can be interpreted with reference to this chart by dividing the product of antenna constant, meter reading and attenuation ratio by the particular frequency of operation.

The accuracy of the instrument is due partly to the maintenance of accurate reference standards for individual factory calibration and partly to the incorporation of an internal calibration signal generator for standardizing the instrument's sensitivity in the field. After tuning in the signal to be measured, the antenna loop is turned away from the direction of signal propagation. The output of the internal calibration oscillator is then switched across the antenna circuit.

Since a three-section variable capacitor tunes the calibration oscillator, antenna stage and heterodyne oscillator simultaneously, only a slight adjustment of a "trimmer" control is required to bring the calibration oscillator frequency into exact correspondence with that of the incoming signal, as indicated through headphones by a zero-beat between the two signals. The IF amplifier sensitivity is then standardized by alternately switching the output meter between two diodes associated with the calibration oscillator and final detector and adjusting sensitivity controls to obtain identical meter readings.

An attenuator is inserted in the IF amplifier input to provide seven ranges of meter sensitivity. Frequency discrimination, the chief difficulty in rf attenuator design, is avoided here by operating the attenuator only at the intermediate frequency of 456 kc. Since the signal is attenuated after conversion to the IF frequency, the converter (or 1st detector) is required to handle a range of antenna signals on the order of 10,000 to 1 in a linear fashion. At some sacrifice of conversion gain, a degree of linearity has been attained that is satisfactory for all normal field strength measurements. In addition, a "loop

attenuator" is provided in the form of a 300-ohm resistor that may be switched in series with the antenna, simultaneously reducing the loop sensitivity and increasing the calibration oscillator output. This is used to prevent overload of the first detector in the presence of very strong fields on the order of 1 to 10 volts/meter.

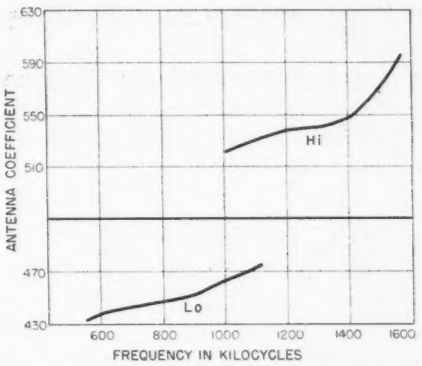
The output meter is sufficiently sensitive (200 μa) to measure directly the small diode current of the linear second detector. However, the standard recording milliammeters used for continuous graphic recording during field strength surveys normally require 5 ma. full-scale current. For this reason a one-stage dc amplifier is connected to the 2nd detector anode circuit.

For recording signal intensities that are subject to wide fluctuations, AVC may be applied to the first IF stage in order to provide an approximately logarithmic, rather than linear, response of this stage to changes in signal level. Proper interpretation of the logarithmic-type measurement, however, must be based on a preliminary calibration of the *rate of change* of sensitivity with signal intensity for the particular measuring range in use.

Battery Operation

The physical layout of the Type 101C field intensity meter is shown in the accompanying photo. There are a number of details of construction and control arrangement that were incorporated as the result of practical experience in field strength measurement. The equipment is designed only for battery operation as either a mobile or portable unit, ordinarily using an external six-volt storage battery for filament supply and for driving an internal vibrator-pack anode supply. The vibrator pack may, however, be replaced by a standard dry cell "A" and "B" battery pack for complete portability, the latter having a service life of about 200 minutes of intermittent operation. With either type of power supply, the maintenance of uniform filament and anode voltages is important in precise work since a decrease in either voltage will affect the output meter reading. Switching facilities are therefore provided to permit use of the output meter for checking these voltages.

Radio field strength measurements are usually made by detecting the voltage induced across a standard antenna by the field to be measured and computing the field strength from the measured voltage and the effective height of the antenna. The calculation of antenna effective height is based on the distance, in meters, between



Typical calibration curves for antenna coefficient (K) covering relation between field strength times frequency to output reading

effective current centers of the particular type of antenna used. Such calculations are usually valid only for measurement of the total radiated magnetic field at distances greater than $\lambda/2\pi$ from the source of radiation. In the case of a loop, antenna height is approximately proportional to $2\pi An/\lambda$, where A is the area (in square meters) enclosed by the loop, n is the number of turns and λ is the wavelength in meters. However, for the unbalanced, shielded loop antenna used with the type 101C, it has been found desirable to determine overall antenna coefficients by actual measurement of each instrument at the factory, using an induction field which is periodically compared with recognized standards. These antenna coefficient measurements are made at fourteen frequencies in the 530 to 1,600 kc "standard broadcast" band, and relate the values of field intensity to the output indicator readings and to the attenuator ratios of the measuring set, in accordance with the following relation:

$K = \epsilon f/MA$, where ϵ is the standard field intensity in microvolts/meter used at the time of calibration, f is frequency in kilocycles/sec., M is the output meter reading obtained at the time of calibration and A the measured voltage-attenuator ratio.

Having determined the value of K by this calibration procedure, it can now be used in the same equation to calculate unknown field intensities from meter readings.

In a test conducted by the National Bureau of Standards on two typical production instruments, it was found that the values of antenna coefficient K measured at the factory agreed with the values determined by the Bureau within $\pm 3\%$. Since individual calibration data is supplied with each instrument relating to the linearity of the first detector and output metering, as well as relationship of indicated to measured attenuator ratios, it would seem reasonable to expect an average consistency of field intensity measurement of about $\pm 10\%$, including interpolation errors. This represents a substantial improvement in accuracy, when compared to standards formerly considered acceptable in this type of work.

Measuring Complex Permeabilities at UHF

A method was developed by M. H. Johnson, G. T. Rado and M. Maloof, of the Naval Research Laboratory, to measure the complex permeabilities of ferromagnetic materials at uhf. The center conductor of a coaxial resonator is made of the material to be investigated and the Q-value and resonant frequency are determined with and without a polarizing field strong enough to saturate the ferromagnetic conductor. Pulse technic and millisecond periods have to be used for these experiments. Attenuation and phase velocity are evaluated from the change in Q-value and resonant frequency and these quantities permit computation of the complex permeability at high frequencies. Permeabilities of approximately 100, much smaller than the dc values, and having a large out-of-phase component, were observed with magnetic iron and Mo-permalloy at 200 mc. The permeabilities as a function of the polarizing field strength were measured.

Test "Guided" Community Broadcasts

Developmental transmitting equipment, operating at 540 kc with 2 to 20 watts power demonstrates supplementary service covering local areas

• How can we take care of the demands of more and still more communication services that want to use our already crowded radio spectrum? Radio engineers wish they knew and the FCC would like the answer, too. Tests now under way at Laurel, Md., in which "guided" radio waves are used over the power line system may point to an answer for one type of community service.

Herbert L. Spencer, consulting radio engineer (and, incidentally, chairman of the Baltimore Section of the IRE), 404 Montgomery St., Laurel, Md., received from the FCC in January a construction permit for portable developmental transmitting equipment to be used in the tests which are now in progress. Originally an output of 10 watts at a frequency within the standard broadcast range was planned; but already it has been found possible to decrease this power to 2 watts on 540 kc and still transmit more than 20 miles. In fact, one of the several problems to solve is how to limit, rather than extend, the range of the experimental transmitter.

Other problems are: (1) Just how complete is community service coverage? Some unexplained "dead spots" are being investigated. (2) How close together can communities using the same frequency be located? It would be fortunate if the range of each transmitter were limited, say to 5 miles, and the "cut-off" be definite. This is known not to be the case. (3) How far away from the power lines can the signal be received? At present, an audible signal is secured at 100 ft. from a power line carrying the radio wave. In open country as one approaches the overhead power line from 100 ft. the signal increases to a peak when directly under the wires, then decreases on the other side in reverse fashion so that a strip 200 ft. wide is served with signal. (Is this pick-up due to the electro-static or radiated field?) (4) How much interference is caused to other services?

Interference Problems

Spencer states that in early tests a harmonic of the transmitted frequency interfered with the Maryland State Police radio net. This harmonic difficulty was eliminated by filters at the transmitter. The problem regarding the fundamental frequency, transmitted in the broadcast band, is one of nicely balancing the input energy to the power system so as to obtain sufficient signal at the receivers and at the same time not radiate a strong enough field to interfere with the reception of a broadcast station on this same, or on a nearby, frequency.

Most broadcast receivers, when tuned to the Spencer station on 540 kc, report signal strengths equal to that received from WBAL, a powerful broadcast station about 20 miles away. It is not necessary at the receiving locations to make any rf connections to the power line but at the sending station power is fed through a condenser to the "high" side of the local 115 volt lighting mains.

Spencer told *Tele-Tech* that the measurements he was making would show whether or not it is practical to look to "guided" radio as a communication means for the small community which is served by an electric power system. He found that the FCC was much interested and he hopes at a later date to give a demonstration.

When asked what kind of a communication need would be met by one of his installations he used as an example the situation of a fire in a community of about 2000 in which there is a volunteer fire department. A municipally-owned, or -leased, speech transmitter would "go on the wires" and broadcast to local listeners, especially the firemen, information concerning the emergency. The usual fire whistle would first be blown to call attention to the fact that emergency news was being transmitted so that listeners could tune their standard broadcast receivers to the especially appointed frequency of their community station. This is only one example; there are many purposes other than emergency uses to which municipalities could put their own "guided" radio broadcasting station—if they had one.

To avoid interference between adjacent communities different frequencies, of course, would be used. This is another problem for which Spencer's experiments will furnish data. Who would assign these frequencies? The FCC would not have direct jurisdiction if, with the low

power used, the radiated field was sufficiently restricted to the immediate vicinity of the power line. In case this idea gains general acceptance, Spencer thinks the FCC would approve the municipal government's jurisdiction over its own station. At present many colleges, some Army camps and others are operating in this manner without FCC licenses. Whether or not they come within the Radio Act depends upon the radio field strength they produce at a given distance from their power line "antennas". The writer knows of no complaints of interference from such systems.

Leased Stations

It is pointed out by Spencer that there may be a considerable demand for community stations on a lease basis, or for outright purchase. From an engineering viewpoint he visualizes being in a position to lease, install and service "guided" radio stations if his tests indicate that such systems meet with FCC endorsement. He stressed the requirement of high quality at the transmitter. It will be unattended. It must accurately maintain its frequency with the aid of improved crystal stabilizing equipment. It must be unusually reliable in operation. For such lower power this does not mean an expensive transmitter; in fact, it should cost less than a deluxe broadcast receiver with phonograph.

It is the writer's hope that such transmitters become common enough to be used along our main traveled highways to supplement the present route markers. This would bear out the prediction he saw in a technical magazine more than twenty years ago. When uncertain of the road the driver would tune his auto radio receiver to a designated frequency and a voice would say: "Three hundred feet ahead is a fork; right to Baltimore, 87 miles; left to Dover, 21 miles."

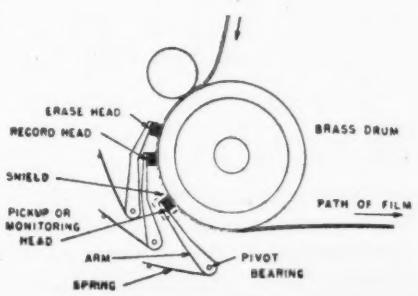
"Guided" radio, or "wired wireless", is by no means new. Many years ago Staten Island enjoyed musical programs sent into homes over wires. A subsidiary of The North American Co. under chief engineer R. D. Duncan, carried on extensive, full-scale tests to bring programs to subscribers, over power circuits, in Cleveland in the early nineteen thirties. In this venture, which terminated unsuccessfully, there were generous funds available for the first-class engineers to build and test a high-power system using the best in modern radio apparatus.

With money, men and equipment available why did not success crown these efforts? It is understood that the greatest difficulty encountered was supplying a usable signal to a sufficiently large percentage of customers' homes. At many locations the signals were extremely strong, at others nothing at all was received. This was due, it is believed, to the signal attenuation encountered in the numerous step-down transformers in the system.

Compare this wired broadcasting system with Spencer's less pretentious type of communication system. The carrier frequency was much lower, for one reason, to reduce radiation. The special receivers, allowing the selection of about four channels, were designed for high-quality reproduction of broadcast programs; they did not have high-gain amplifiers, and they were connected by radio coupling units to the light line in the customer's home. The signal level in these homes was considerably affected by variations in load on the lighting circuits. The object, of course, was to furnish, on a rental basis, equipment which would reproduce a choice of broadcast programs of high quality, devoid of advertising, free from static with technical excellence approached only some years later by FM transmitters.

Magnetic Sound for Movie Film

It appears as though magnetic recording may soon invade the motion picture field where photographic development of optically recorded sound tracks has been universal since the early disc recordings with their synchronizing troubles went out shortly after sound movies first became practical about twenty years ago. Motion picture film with a magnetic track coated directly on the film has been produced and demonstrated. Marvin Camras, pioneer developer of magnetic wire recording methods for the Armour Research Foundation, tells about the new process in the Journal of the Society of Motion Picture Engineers.



Arrangement of recording, erase and reproducing heads in magnetic recorder for film.

The process he describes is one in which powdered magnetic material is coated either on the emulsion side or the back side of the film in the place of the usual optical sound track. The magnetic material is waterproof and may be applied before the film is processed through the usual developing solutions; it may also be applied to finished, existing, films to which sound is to be added.

Describing the process, Camras points to these advantages of magnetic recording: (1) the magnetic record can be erased and the film used over again, (2) parts of the sound track can be edited, erased if necessary, and new or corrected sound dubbed in; (3) monitoring can be done immediately, and (4) no processing is necessary. Additional advantages are simplicity, low cost, and insignificant overmodulation distortion.

Two of the main disadvantages he reports, are (1) possibility of wear since the head contacts the record, and (2) the technical performance of the magnetic tape at the present time is not equal to the best optical methods. Theoretically, however, the magnetic type of system should perform as well.

The magnetic sound record cannot be duplicated by the same direct contact printing process as in the optical sound record. However, since each release must be run through a printer anyway, the mag-

(*Continued on page* 113)

Effect of Trees on HF Signals

In continuous measurements over 3½-year period, foliage reduced average signal strength by 25 db at frequency of 9.2 centimeters

● From England has come interesting evidence that trees do affect the propagation of very short radio waves. Dr. E. C. S. Megaw, reporting on work done at the Admiralty Signal Establishment at the Paris meeting of the Union Radio Scientific Internationale in November, 1946, tells of the effects, measured in db at the receiver, of cutting the top out of a large tree

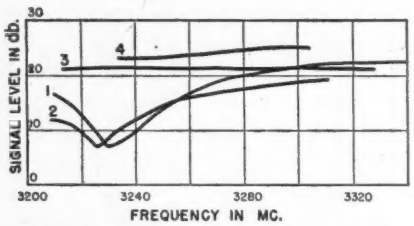


Fig. 1—Effects produced by a complex barrier. Frequency used over path is plotted against received signal. For seasonal variation compare average of curves 3 and 4 with curves 1 and 2. Curve 1 (Dec. 31, 1943) and curve 2 (Jan. 31, 1944) are typical of winter. Curve 3 (June 19, 1944) and curve 4 (Oct. 9, 1944) are typical of summer.

that was directly obstructing the waves reaching the receiving antenna.

First, to get a general idea of the transmission loss on very short waves a paragraph will be quoted from his report:

"During trials overland, 1937-39, of 50 cm. equipment, many observations were made of the effects of hills, buildings, bridges, etc., using omni-directional aerials, the receiving aerial being about 14 ft. above the ground in a vehicle. Interference effects from trees and buildings were very marked, and would have been much reduced with a directional aerial.

"With complex obstacles in built-up areas it was found that there was a general level of "diffused" field which provided perfectly satisfactory communication with sufficient transmitter power. With about 5 watts radiated from 140 ft. above ground and a receiver noise factor of the order of 20 to 25 db., complete coverage was obtained up to 1 mile in a suburban area with small hills.

"With the receiver on high ground, not necessarily in optical range, good signals were obtained up to 5-8 miles. Over one non-optical path 5½ miles long, with a hill and a building rising to 58 ft. above the line of sight 3400 ft. from the transmitter, the diffraction loss was about 15 db."

The very expressive term "diffraction loss" is one not often seen in our technical discussions on this subject.

Effect of Foliage

To quantitatively measure this it is necessary to have year-around observations. The data herewith resulted from continuous measure-

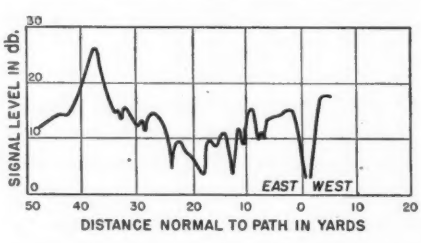


Fig. 2—Variation in signal along a line normal to the path when antenna is moved east or west of original location

ments over nearly 3½ years. The wavelength used was 9.2 cm., considerably shorter than that used for FM or television broadcasting and for this reason the magnitude of the attenuation observed would be larger, but the effect of trees is thus brought into stronger relief.

The transmitter was located 730 ft. above sea-level at Haslemere, the receiver at 200 ft. at Wembley, 38 miles away. The line of sight transmission was obstructed only by a barrier of trees and a few houses surrounding the receiving antenna, a 4-ft. paraboloid. Measurements indicated that this barrier gave an average reduction in signal level over the year that was about 25 db. below the free-space signal level.

At the beginning of the series of measurements the path at the transmitting end was obstructed by the top of a single tree 200 ft. distant. This was roughly the same size and shape as the radio beam. Removing the top of the tree increased the received signal strength by 11 db. After 3 years the tree was trimmed again and it was found that the growth during this time had inserted a loss of only 1.5 db.

It was confidently expected that when the leaves fell from the trees forming the barrier in the path to the receiving antenna that there would be an increase in signal strength. When November came and this happened the daily mean level of signal actually went down, not up! There was a search for experimental errors. None were found. Dr. Megaw reported that he then suspected that the change in signal level was caused by partial cancellation at the receiver due to an out-of-phase signal arriving over a path differing from the direct path.

(*Continued on page* 109)

Remote Control Telephonograf

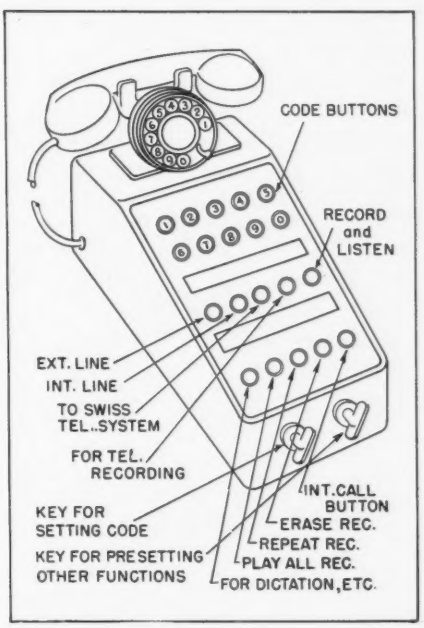
Ingenious Swiss device automatically answers telephone calls, records two-way conversations up to 30 minutes, plays back when properly coded

• At various times during the development of telephony it has been suggested that speech recording facilities would be a useful auxiliary to the regular telephone service, as a "robot secretary" to receive messages in the absence of a telephone subscriber. Until recently, however, no system proposed has been sufficiently foolproof and automatic to obtain the official approval of a telephone company—a rather basic requirement for general adoption of such a device. Announcement that a new remotely-controlled magnetic wire recorder has been adopted by the Swiss Telephone Service has therefore renewed interest as indicating the feasibility of such equipment.

The new telephone recorder, or "telephonograf," has been christened "Ipsophone" by its manufacturers, the Oerlikon Machine Tool Works of Buhrle & Co., Zurich, and is now available to telephone subscribers in Switzerland on a five-year contract basis at a monthly rental cost of 150 Swiss francs (about $41). Its development was carried to the commercial stage by Dr. Ernst Keller and associates of the Oerlikon Works and is based on patents issued to a German inventor named Muller.

A summary of the various functions performed by the Ipsophone may reveal why this particular device has achieved more commercial success than its predecessors, as well as considerable international notoriety:

(1) Any number of messages up to a total of thirty minutes may be recorded on the Ipsophone by any party dialing the proper number.



Ipsophone, leased to telephone subscribers, functions as a robot secretary

(2) The recorded messages may be played back over the telephone system to any person knowing the private code numbers for a particular Ipsophone. These code numbers are selected by the subscriber prior to leaving the office and may be changed by him as frequently as desired to insure privacy of the recorded messages.

(3) Messages may be erased by the subscriber, either on his return to the office or from a remotely located standard telephone, thus clearing the thirty-minute record for the receipt of further messages.

(4) Provision of two separate recording mechanisms at each installation enables playback of any message within one minute after the playback relay is actuated by a vocal command.

(5) The Ipsophone also can be used as an office dictation machine; as a message center for business associates, or for recording business conferences either in the office or by the linkage of various telephones in a conference network. If there is a lull of more than twelve seconds between messages, the recorder automatically stops until restarted by a voice-operated relay.

The recording medium is a steel wire, with low background noise characteristics, and an ingenious rewinding feature. The first reel, having its own recording and erasing mechanism, has a time capacity of five minutes, after which recording operations are transferred to a twenty-five minute spool of wire while the first reel automatically rewinds at five times normal speed. If the playback relay is actuated before the first five minutes of recording is complete, it will, of course, be necessary for the listener to wait a maximum of one minute for completion of the rewinding operation. If more than five minutes of messages have been received, however, no delay in playback is involved, since the five-minute reel will already be rewound and the twenty-five minute reel automatically rewinds during the five minutes required to reproduce the contents of the first reel.

As a guarantee that no unauthorized persons may listen in on the recorded messages, a three-digit code is used, which must be preset by the subscriber by unlocking a code mechanism. Any three of the ten code buttons may then be depressed after which the key is withdrawn. Since there are 1,023 possible combinations of the three-digit code, playback by unauthor-

(*Continued on page* 108)

Survey of Wide Reading

Electronic news in the world's press. Review of engineering, scientific and industrial journals, here and abroad

The "Siemens-Hell-Schreiber", Facsimile-Radiotelegraph*

This German radiotelegraph system reproduces the letters of the alphabet by a 7-row, 7-column scanning facsimile method. Each letter is broken down as illustrated for "E" in Fig. 1 and reproduced column by column. The signal pulses corresponding to the letter "E", Fig. 2, are obtained by scanning the pattern of the letter in successive columns, starting at the lower left corner, rectangle A-1, moving up to rectangle A-7, scanning the next column beginning with B-1 and so on.

The current pulses in the transmitter are obtained by rotating cam-wheels, Fig. 3, each wheel having protruding cams on the circumference corresponding to the pulse representation of one letter; compare the cam-wheel for "E" in Fig. 3, and the representation in Fig. 2. All cam-wheels are mounted on a motor-driven rotating shaft, and each cam-wheel is connected to a separate lever system.

The machine is operated by a keyboard, resembling a typewriter keyboard. Striking key "E", for example, will release the associated

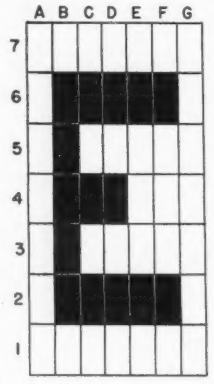


Fig. 1—Illustrating break-down of letter "E" for facsimile transmission

lever system thereby establishing contact between the contact lever and the cam-wheel for the letter "E". With this adjustment, a circuit will be closed and a current pulse generated whenever the contact lever is raised by a cam of the rotating cam-wheel.

In the receiver, Fig. 4, the modulated currents control the movement of an electromagnet which in turn presses a dull blade against the recording strip. Above the strip is mounted a writing spiral which revolves with an angular velocity equal to seven times the angular velocity of the shaft carrying the cam-wheels in the sender. Inspection of the figure will reveal that the original "E" as shown in Fig. 1 is reproduced on the paper strip in a slanting position.

In an alternative development, lever systems and hand operation are replaced by a punched strip

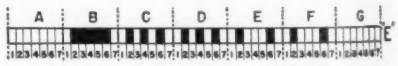


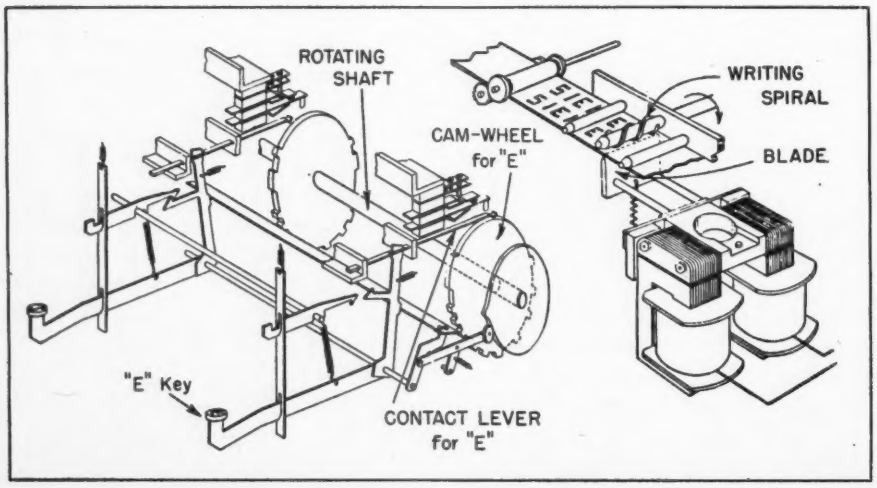
Fig. 2—Signal pulses obtained by column by column scanning of pattern for letter "E" shown in Fig. 1

system and automatic operation where holes, corresponding to the pulses, are punched in a strip which is then passed through a properly adapted sender.

The transmitted current pulses may be ac or dc. At the beginning of each transmission a 0.5 sec pulse conditions the receiver for operation while a 7 sec pulse at the end of the message renders the receiver inoperative.

Fading and interference do not, as a rule, disturb "Hell-Schreiber" communication, because each letter is made up of several signals and the signs are readable. Distortion will be noticed immediately, preventing wrong interpretation of

Fig. 3 (left)—Sender of facsimile-radiotelegraph. Fig. 4 (right)—Printing mechanism in receiver of facsimile-radiotelegraph



*H. Schulz (Telegraphen-, Fernspruch-, Funk- und Fernsehtechnik, Berlin, Germany, Vol. 30, No. 2, pp. 52-57)

a message, which is not true for conventional Morse telegraphy. However only about five letters per second can be transmitted.

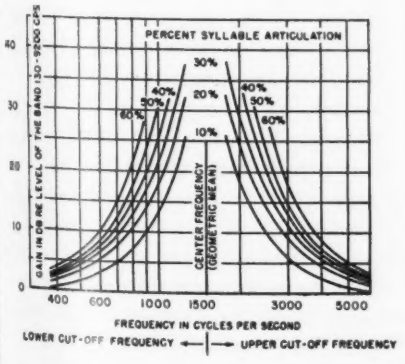
Dependence of Intelligibility on Pass Band and Noise Level

J. P. Egan and F. M. Wiener (The Journal of the Acoustical Society of America, October, 1946, pp. 435-441)

Articulation tests were conducted with a view to establishing quantitative relations between intelligibility of speech (measured in percent syllable articulation, i.e., the percentage of syllables correctly recognized by a listener), pass-band (specified by the bandwidth and the geometric center frequency, i.e., the geometric mean of the two cut-off frequencies), and speech-to-noise ratio.

Two masking noise spectra were studied, one with a constant frequency distribution and the other with decreasing noise level as the frequency increases. Further the two conditions of the listener being in a noisy location and the talker in a quiet surrounding, and vice versa, were tested separately. Note that speech frequencies in the central range are more important for intelligibility than are the low or the high frequencies. An extensive amount of data on the influence of the location of the center frequency as well as on the bandwidth were accumulated.

The curves in the diagram illustrate constant percentage syllable articulation, i.e., intelligibility, as a function of the pass-band and of

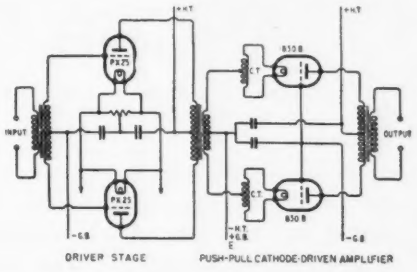


the gain in decibels over the 130 to 9200 cycle band. Each contour indicates the change in gain which compensates for a change in band width at a desired articulation score. To a reasonable approximation the same contours can be used for other center frequencies within the 1000 to 2000 cycle range by shifting the entire family of curves along the logarithmic frequency scale.

Class B Audio-Frequency Amplifiers

F. Butler (Wireless Engineer, London, England, January, 1947, pp. 14-19)

The push-pull cathode-driven power amplifier is recommended for supplying audio signals to high-power modulators. Its input impedance is very low and the additional parallel loading represented by grid-current flow at class B operation is comparatively small. With the tubes shown operating at maximum ratings, the output should be nearly 200 watts. Details of circuit design are included.



The Twin Triode Phase-Splitting Amplifier

J. D. Clare (Electronic Engineering, London, England, February, 1947, pp. 62-63)

The circuit illustrated is intended to supply two 180 deg. out-of-phase voltages of equal amplitude for push-pull operation. It is shown that if

$$\mu_2 R_k R_2 = \mu_2 R_k R_1 + r_{p2} R_1 + R_2 R_1,$$

a balanced push-pull output $e_{01} = -/e_{02}$ is obtained. In the circuit shown in the drawing, the operating point for the 6SN7 double-triode is so chosen that the internal plate resistances r_{p1} and r_{p2} are 10,000 ohms and the dc plate current component is equal to 2.5 ma for each tube. From this circuit arrangement and an input voltage $E_i = 3.1$ volts, 24.5 and 24.6 rms volts output for a push-pull drive can be obtained. Flat frequency response within the range of 50 cycles to 15,000 cycles is assured to 0.1 db.

It is of interest to evaluate the variation in amplitude balance for a variation by k percent of μ_2, the amplification factor of the second

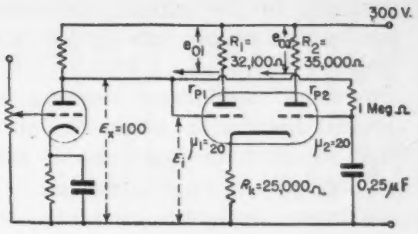


Fig. 1—Twin triode phase-splitting amplifier supplying two 180° out-of-phase voltages

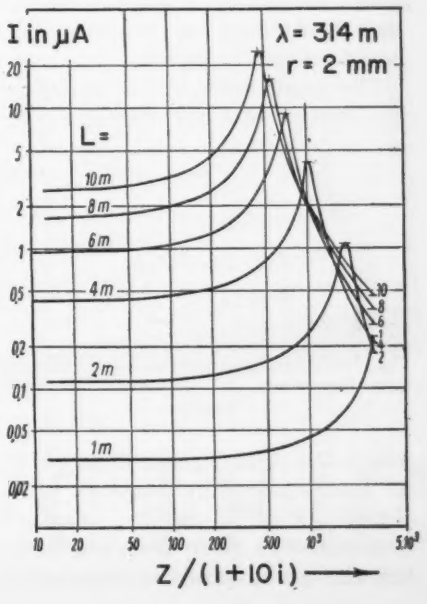
triode. The expression for the percent change in the ratio e_{01}/e_{02} is $100k(R_2-/R_1)/R_2(100+k)$. For the resistance values indicated in the drawing, a 10% change in the value of the amplification factor μ_2 will result in a 0.75% change in the ratio of the output voltages e_{01}/e_{02}.

Formula for Receiving Antennas

J. Mueller-Strobel and J. Patry (Schweitzer Archiv fuer angewandte Wissenschaft und Technik, Solothurn, Switzerland, July, 1946, pp. 201-213)

Based on Halen's theory, the following formula for the current, I, in a straight antenna is derived: $I = ic\pi L^2 E \ (A+3) / [\lambda A^2 + ic\pi LZ \ (A+3.386)]$, where i is the imaginary unit, c the velocity of light, L the half length of the receiving antenna, E the field strength component of the incoming wave parallel to the antenna, assumed to be constant over the length of the antenna, $A = 2 \ ln \ (2L/r)$, r the radius of the antenna, and Z the im-

Fig. 1—Antenna current as function of coupling circuit impedance for different antenna lengths



pedance of the circuit connected across the center gap of the antenna.

A more complicated formula for special distribution of the incoming field strength in space also is presented and it is shown that the maximum antenna currents are practically the same for constant incoming field strength and for one that increases with increasing height to more than twice its minimum value. This indicates that the field strength distribution in the incoming wave is of little importance.

It is assumed that $2\pi L$ does not exceed 0.19λ, reducing the error introduced by neglecting higher order terms in series developments to 5%. The figure illustrates the antenna current as a function of the impedance of the receiver circuit connected across the antenna gap, assuming its imaginary part to be ten times its real part, for antennas from 1 to 10 meters half length, a wavelength of 314 meters, and an antenna radius of 2 mm.

Design of Broad Band IF Amplifiers

Richard F. Baum, Raytheon Mfg. Co. (Journal of Applied Physics, June 1946, pages 519 to 529)

The paper deals with the design of stagger-tuned, broad-band, IF amplifiers. The derivation is based on a reference circuit which is resonant at the center frequency, f_o, has a shunt resistance R, and a figure of merit, Q. Detuning is assumed to be proportional to the frequency deviation from the resonance frequency. This approximation introduces an error at very broad frequency bands.

The band width $2\triangle f_o$, is defined by that frequency deviation for

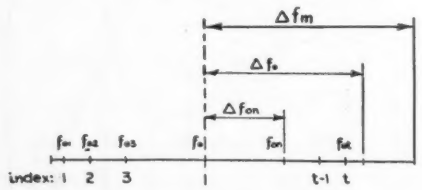


Fig. 1—Explaining symbols for frequencies important in wide-band amplifier design

which the desired gain falls off by an admissible gain tolerance of d_o Nepers (Figs. 1 and 2). Further considered as given design quantities are the ratio of the bandwidth,

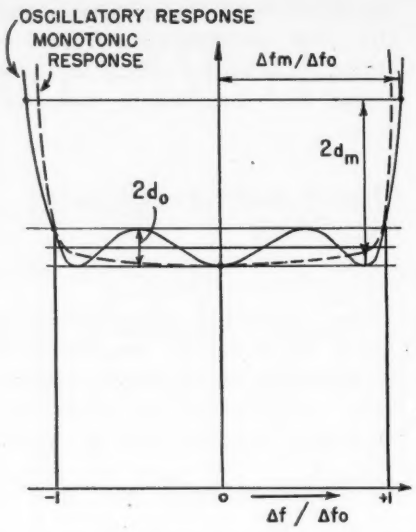


Fig. 2—Response curves of wide-band amplifier

$2\triangle f_o$, to mid-band frequency, f_o, the amplifier gain G, and a prescribed attenuation of d_m Nepers at a bandwidth of $2\triangle f_m$. The index n refers to the nth circuit of the amplifier; each individual circuit is adequately defined by its shunt resistance, R_n, its resonance

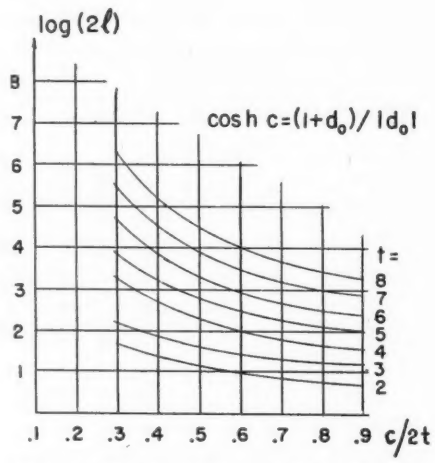


Fig. 3—Graph for log (2l) facilitating evaluation of shunt resistance

frequency, f_{on}, and its figure of merit, Q_n. $\triangle f_{on}$ is the displacement of the nth resonance frequency from the mid-band frequency f_o. The required response curve has either an oscillatory form or a monotonic form (Fig. 2). Different design formulae correspond to the two cases.

The first step is to determine the minimum number of circuits, t, by means of the formulae

$$2t \geq [2d_m - \ell_9(d_o/2)]/\cosh^{-1}(\triangle f_m/\triangle f_o)$$

$$2t^* \geq [d_m - \ell_9(2d_o)]/\ell_9(\triangle f_m/\triangle f_o)$$

where d_m, in Nepers, is the attenuation required at a given frequency displacement $\triangle f_m$ from the mid-band frequency, f_o. The asterisk refers to monotonic response.

The design formula for oscillatory and monotonic response curves, respectively, are summarized below:

$$\triangle f_{on}/\triangle f_o = \cos[(2n-1)\pi/2t]\cosh(c/2t)$$

$$\text{WHERE} \quad c = \cosh^{-1}[(1+d_o)/|d_o|]$$

$$Q = f_o/2\triangle f_o \sinh(c/2t)$$

$$Q f_{on}/Q_n f_o = \sin[(2n-1)\pi/2t]$$

$$\triangle f^*_{on}/\triangle f_o = \cos[(2n-1)\pi/2t]\cdot[2d_o]^{-1/2t}$$

$$Q^* = f_o(2d_o)^{1/2t}/2\triangle f_o$$

$$Q^* f_{on}/Q^*_n f_o = \sin[(2n-1)\pi/2t]$$

For a desired gain, G_o, at the mid-band frequency, f_o, the shunt resistances, R, of the reference circuits are found from the formulae

$$\ell_{og_{10}}(2_9 R) = [\ell_{og_{10}}|G_o| + \ell_{og_{10}} 2\ell]/t$$

$$G_o^* = (_9 R)^t$$

$$R_n/R = Q_n f_o/Q f_{on}$$

for oscillatory and monotonic response respectively log (2l) may be taken from the graph in Fig. 3, g is the tube transconductance.

The result is extended to double tuned stages. A numerical example is included.

490-Mc Color-Television Transmitter

N. H. Young (Electrical Communication, December, 1946, pp. 406-414)

A 490-mc color-television transmitter with a peak power output of approximately 1 kilowatt and a maximum average output of 600 watts was developed for the Columbia Broadcasting System and installed on the 71st floor of the Chrysler Building. Transmission of all frequencies within the 20 cycle to 10 mc band was required with an attenuation of the sidebands in the output stage of less than 2 decibels at 10 mc from the carrier. Design features of the oscillator, the video amplifier and the modulator are explained.

The video amplifier output stage has two 6C22 tubes in parallel, connected as cathode followers. In the video amplifier stages, feeding the modulator output stage, a capacitor connects plate and grid of successive stages. To insure transmis-

NOW you can get Sylvania quality in transmitting tubes too!

SYLVANIA INTRODUCES THE TYPE 3D24

BEAM POWER TETRODE WITH ELECTRONIC GRAPHITE ANODE

First of Sylvania's new line of transmitting tubes, the 3D24 is a four-electrode amplifier and oscillator with 45 watt anode dissipation. An outstanding development is the electronic graphite anode, which allows high plate dissipation for small area and maintains constant inter-element relationship and uniform anode characteristics.

The 3D24 may be used at full input up to 125 Mc — maximum permissible frequency will be announced later upon completion of tests.

OTHER FEATURES INCLUDE:

1. **Lock-In base.** Short leads, no soldered joints.
2. **Top cap providing for short path, greater cooling by radiation and convection, resulting in a cooler seal.**
3. **Thoriated tungsten filament, giving high power output per watt of filament power.**
4. **Vertical bar grids.** #1 grid supplied with two leads for better high frequency performance. #2 grid provided with heat-reflecting shield for greater dissipation, low grid-plate capacity.
5. **Low interelectrode capacity.** No neutralizing needed with proper circuit arrangement.
6. **Hard glass envelope.** Permits high power for small size.

The 3D24, a product of the Electronics Division of Sylvania, has interesting potentialities in amateur, police, mobile and marine radio.

MECHANICAL SPECIFICATIONS

Type of cooling	Air—radiation and convection
Mounting position	Vertical, base down or up
Length overall	4.3 inches max.
Seated height	3.769 inches
Diameter	1½ inches
Net weight	1.3 ounces

ELECTRICAL CHARACTERISTICS

Filament Voltage	6.3 volts
Filament Current	3.0 amperes
Amplification Factor	50
Direct Interelectrode Capacitances	
Grid-Plate	0.2 μμf max.
Input	6.5 μμf
Output	2.4 μμf

3D24 TYPICAL OPERATING CONDITIONS

R. F. Power Amplifier and Oscillator—Class C Telegraphy

Characteristic	C.C.S.	C.C.S.
D. C. Plate Voltage	1500 volts	2000 volts
D. C. Control Grid Voltage	—300 volts	—300 volts
D. C. Screen Grid Voltage	375 volts	375 volts
D. C. Plate Current	90 ma	90 ma
D. C. Control Grid Current	10 ma	10 ma
D. C. Screen Grid Current	22 ma	20 ma
Peak R. F. Grid Input Voltage	400 volts approx.	400 volts approx.
Full Driving Power	4.0 watts approx.	4.0 watts approx.
Plate Power Output	105 watts	140 watts

Direct inquiries to Radio Tube Division, Emporium, Pa.

SYLVANIA ELECTRIC

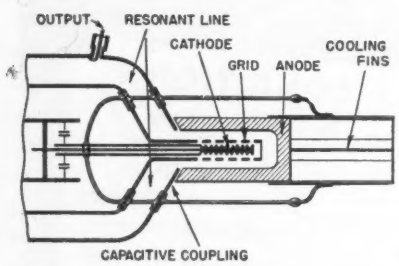
MAKERS OF ELECTRONIC DEVICES; RADIO TUBES; CATHODE RAY TUBES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES; ELECTRIC LIGHT BULBS

sion of the dc component and to secure satisfactory low frequency response, a regulated power supply forms part of each interstage network. A high resistor is inserted between the plate of the first tube and the positive terminal of the power supply, another high resistor connects the other side of the coupling capacitor to the negative terminal of the power supply. The positive terminal is further connected to ground and to the grounded cathode of the second stage through a capacitor. Dc and low frequency components will be transmitted over this power supply path, while high frequency transmission, for which another compensating network is provided, will not be affected.

UHF Tube

G. P. Chevigny and E. Labin, Federal Telephone and Radio Corp., (F) February 16, 1942 (I) June 25, 1946, No. 2,402,601

The concentric resonant line or cavity resonator constituting the resonant plate-grid circuit extends inside the vacuum tube envelope where a capacitive coupling is provided between the plate and the resonant circuit while the grid is directly connected. This arrangement keeps the dc plate voltage off the resonator and reduces tendency



to sparking between the coupling capacitor plates which is less likely to occur in vacuum than in air. Tuning of the resonator may be performed outside the vacuum tube. Two similar tubes of the type described may be readily connected together.

Bunching Theory

E. Feenberg and D. Feldman (Journal of Applied Physics, December, 1946, pp. 1025-1037)

The theory of small signal bunching for a parallel electron beam shaped as a narrow band and traveling in a rectangular conducting tube is developed. Charge density variations and their effects are taken into account, necessitating integration of the field equations and of the equations of motion of the electrons in the field. Modulation by either a gap in the rectangular tube or two grids extending across the tube are treated.

DC Potential Affects RF Discharge

A. A. Varela (The Physical Review, January 15, 1947, pp. 124-125)

When experimenting with low-power radar systems, a dc potential, less than that required to initiate a discharge, was applied to a radio frequency gaseous discharge switch to speed up ionization and deionization and to increase the intensity of the discharge. The tests were conducted at a frequency of 120 mc with 5 microsecond pulses at a rate of 60 per second.

It was observed, however, that a considerably stronger radio frequency voltage was required for the initiation of the discharge, that the admittance of the discharge was lowered, though the recovery time was shortened by the dc bias. Switching and modulation of high frequency currents are possible fields for application of the phenomenon.

Behavior of Dynatron at High Frequencies

G. A. Hay (Wireless Engineer, London, November, 1946, pages 299 to 305)

An attempt is reported to extend low-frequency, dynamic resistance measurements of tuned circuits by means of dynatrons to the high frequency range up to 100 mc. An approximate calculation of the electron transit time between plate and screen of a conventional tetrode gives a value in the region of 3×10^{-10} seconds; this is unlikely to have any disturbing effect below 100 mc. Any irregularities in the behavior of a dynatron, it is inferred, must be attributed to interelectrode capacitances, lead inductances, and frequency-dependent dielectric losses. Experimental results confirmed this conclusion. Use of the dynatron for measuring resistances at frequencies above 100 mc, however, would require specially designed tubes.

Auto-Transformer Coupling for Television

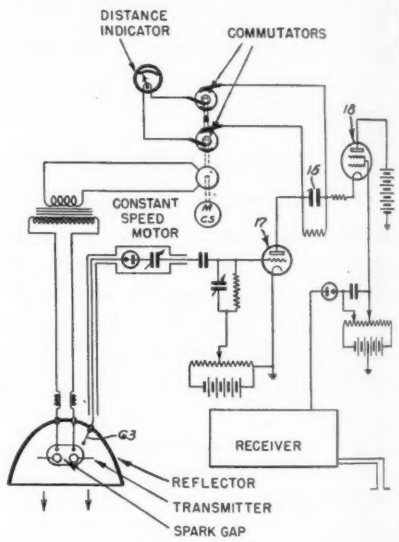
P. Feldmann (Electronic Engineering, London, January, 1947, pp. 21-22)

Auto-transformers may be used to couple television receiver stages. Expressions for effective output resistance, gain, condition for maximum gain, and bandwidth are derived.

Radar Altimeter

Lee de Forest, (F) August 23, 1941, (I) November 12, 1946, Patent No. 2,410,868

An altimeter is described which is based on the radar principle of measuring the time interval between emission of a short wave train and its reception after it is



reflected from a distant object. The altimeter may be mounted on an aircraft to determine its distance from ground. To continuously indicate correct distance — which may vary rapidly as the airplane ascends or descends—the apparatus is adapted for a very short operating cycle.

Referring to the drawing, a vacuum tube 17 is normally biased beyond cut-off. If the spark gap discharges, antenna 63 picks up a signal which is rectified and applied to the grid of tube 17, making it conducting. Current will then flow through tube 17, capacitor 15 and tube 18, charging capacitor 15. Reception of the reflected signal will interrupt current through tube 18 and stop charging of capacitor 15. At a certain time interval after discharge of the spark gap, the constant-speed motor will have ro-

tated the commutators so that the charged capacitor 15 is connected across the measuring instrument which may be calibrated in distance units. Further rotation of the motor will cause another discharge and the operating cycle will be repeated.

Multiple-Trace CRO Equipment

W. Wilson (Electrical Engineer and Merchandiser, Melbourne, Australia, September 16, 1946)

Several cathode-ray oscillograph traces may be obtained on the same film either by arranging several tubes to record on the same film, by using double-beam tubes, or by controlling one beam so as to trace two curves.

In the double-beam tube, the two beams have one common horizontal deflection field, while their vertical deflection is controlled by separate deflection systems. The third method involves alternately connecting the vertical deflection system to two controlling circuits at such rapid rate that two apparently continuous traces are produced. The switching frequency may be chosen much higher than the sweep frequency, the beam rapidly jumping from one curve to the other; alternatively, the switching frequency may be made identical or an integral multiple of the sweep frequency, in which case the beam follows one curve for one or several consecutive sweeps and then changes to trace the other curve.

Pulse-Time Modulation Equipment

D. D. Grieg and A. M. Levine (Electrical Communication, Vol. 23, No. 2.)

Terminal equipment for a 2-way, 24-channel system, utilizing pulse-time modulation and time division multiplexing, is described. Multivibrator modulator, phase-shift modulator, and particularly the Cyclophone and its associated circuit elements are discussed.

The Cyclophone* is essentially a cathode-ray tube with an apertured plate and 25 dynodes lined-up with the apertures, against which the electrons impinge after passage through the apertures. It provides 25 series of equidistant saw-tooth shaped pulses corresponding to 24 audio signal channels and one marker channel. Clippers cut out slices from these pulses the width of which is controlled by the audio amplitude so that time-modulated pulses are obtained by subsequent differentiation and clipping.

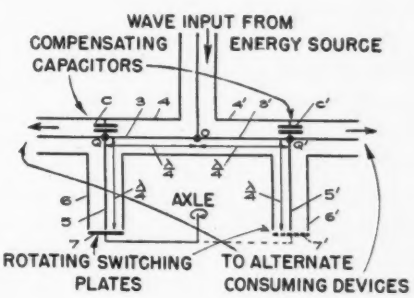
Demodulation may be accomplished by a multivibrator or preferably also by a Cyclophone where the electron beam rotates at the recurrence frequency of the pulses in the separate channels, derived from the marker pulses, and the time-modulated pulses are applied to the control grid. Each dynode is connected to a low-pass filter which supplies an audio output. Operation of this channel-separator demodulator is explained in some detail.

*"PT Modulation for Multiple Transmission", Electronic Industries, November, 1945, p. 90.

Transmission Line Switch

D. C. Espley, the General Electric Co., Ltd., (F) June 7, 1941, (I) July 30, 1946, No. 2,404,832

Some high frequency switches make use of quarter wave transmission line stubs 5, 6 which are short-circuited at regular intervals to



provide an infinite impedance at their other end, permitting passage of the wave to the consuming device fed by the transmission line 3, 4 to which the stub 5, 6 is attached. No energy will travel along this branch of the transmission line during the time interval the quarter-wave stub 5, 6 is left open. Similar conditions obtain for transmission 3′, 4′ and 5′, 6′ when plate 7 is rotated into position 7′.

However, since plate 7 cannot be constructed to reduce the terminal impedance to zero, a residual capacitance between central conductor 5 and plate 7 as well as between outer conductor 6 and plate 7 is unavoidable. The present invention proposes to neutralize the effect of this residual capacitance, which will be transposed into an inductance at the point Q, by a suitably dimensioned capacitance C connected in parallel to the stub 5, 6. Capacitance C′ serves the same purpose with respect to the other transmission line branch.

If the switching stubs are one half-wavelength long, the terminal capacitances will appear as capacitances at point Q, Q′ and are preferably compensated by series inductances of proper value which will not interfere with the passage of the waves through the transmission lines when the stubs are open.

Noise and Sensitivity of Velocity-Modulated Tubes and Magnetrons

F. Luedi, Brown Boveri & Cie., Baden, Switzerland (Helvetica Physica Acta, Basel, Switzerland, Vol. XIX, No. 5, September, 1946, pages 355 to 374)

The formula for the shot effect in a temperature limited diode, $i^2 = 3.18 \times 10^{19} I \Delta f$, where i is the rms fluctuation current in amperes, I the diode current in amperes, and Δf the frequency band considered, is extended to velocity modulated tubes and magnetrons.

The above formula is shown to hold for long waves in velocity-modulated tubes and magnetrons, while for short waves the expression for i^2 has to be multiplied by the square of the number of electron transitions between two neighboring electrodes (grids of a velocity-modulated tube or plates of a magnetron).

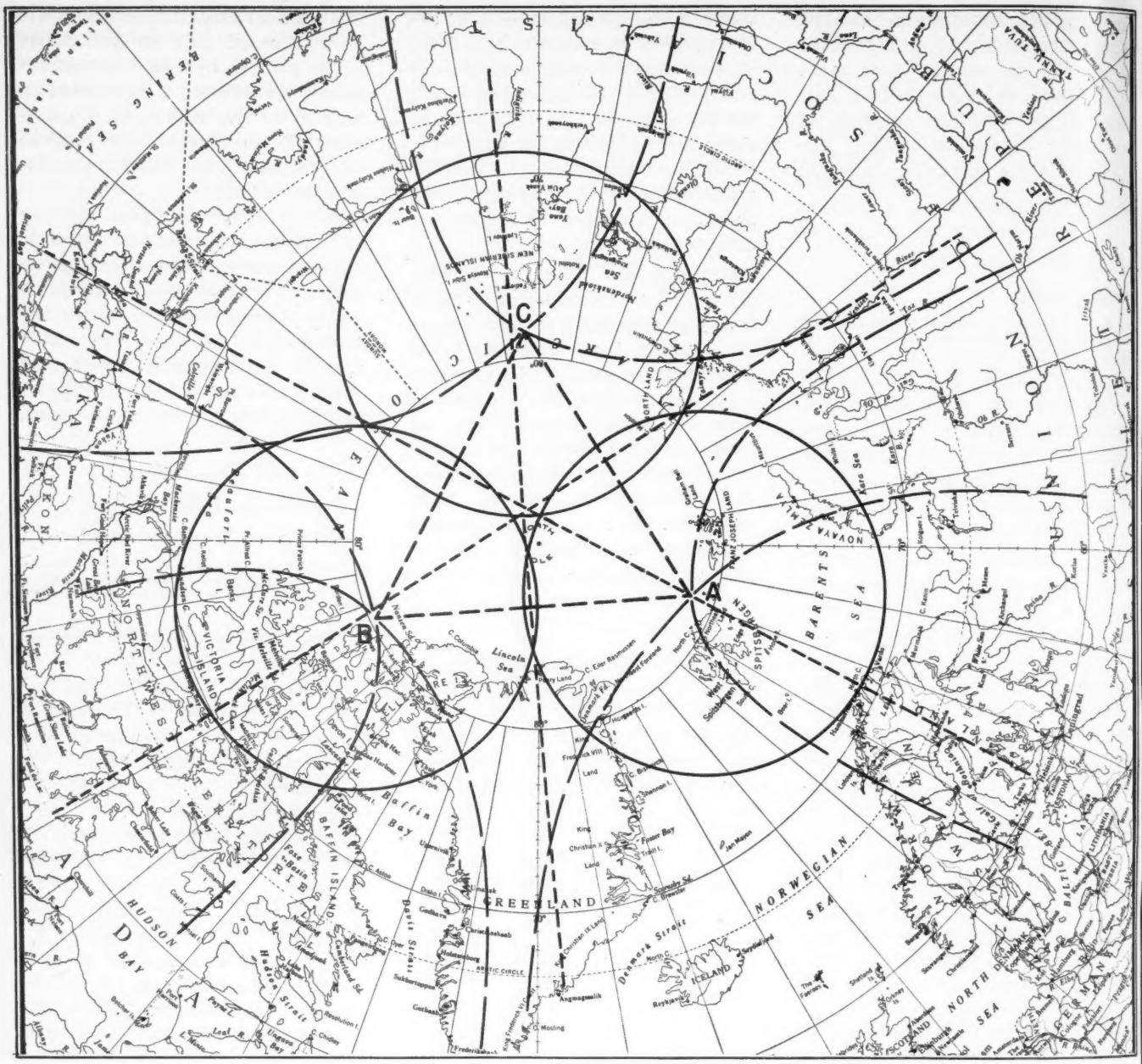
Formulas for optimum sensitivity, or the minimum signal intensity that can be distinguished from the noise under optimum conditions, are given and numerical examples are included.

Simple Ground Propagation Formula for 7 Meter Waves

P. Williams (Electronic Engineering, London, England, January, 1947, pp. 17-20)

A simple law has been devised which permits one to evaluate the field strength at a given distance from a transmitter, when the intervening territory lies below the level of the ground at transmission and reception points. To account for ground irregularities an equivalent receiving antenna height is computed as follows: find the

(*Continued on page* 118)



Lighter-than-Air Loran Ships

• In a recent lecture before the polar navigation subcommittee of the Institute of Navigation, Commander A. D. Jackson Jr., of the U. S. Navy, advocated the establishment of polar air lanes and modern air-surface search and rescue facilites in the North Polar region. Pointing out that within 60 degrees of the North Pole lie 98% of the world's industry and 90% of its population, he stressed the coming worldwide importance of the North Polar air route between principal cities of the various continents.

To implement these facilities, Commander Jackson pointed out the advantages of rigid airships permanently stationed to guide, rescue and service the air traveler over the pole. The electronic phase of the suggestion would be the establishment of Loran grids over this area and for this purpose airships stationed about the 80th parallel as shown on the accompanying map would be in an excellent position to cover the area adequately. The proposed coverage is shown in large circles at the locations mentioned as suitable for the purpose.

Contrary to popular impression, once an altitude free from surface weather conditions has been reached, all available reports indicate a smooth stable air mass with 300 miles visibility to be the common weather in the region. When it is additionally considered that a lighter-than-air ship enjoys a lift increase of 1% for each 5 degree decrease in air temperature and that it has enormous reserve power, it seems to be a "natural" for this service.

NEW VHF NAVIGATION SYSTEM PROVED*

*** First Demonstrations at Indianapolis Successful in Fog and Snow Storm**

On January 4-5, and again from January 20-23, a new VHF airborne receiving and indicating system, giving ADF type presentation, was successfully demonstrated in conjunction with the CAA's Omnidirectional Range at Indianapolis. The radio and instrumentation equipment was designed and built to specifications of Aeronautical Radio Inc. by the Collins Radio Company.

In full cooperation with commercial aviation in its untiring efforts to establish improved air navigation facilities, the Collins 51R system was speeded to completion by intensive engineering effort, and is the *first* of its type to be demonstrated. ARINC's Radio Equipment Committee and commercial airline engineers witnessed the earlier demonstration in the Collins flight research plane, a Beechcraft 18S. Fog and low-hanging clouds precluded any but instrument flying and provided ideal conditions for proving the effectiveness of the system.

The second demonstration was at the request of the Air Transport Association's Air Navigation Traffic Control Research Group for ATA members. The equipment was installed in ATA's experimental plane, a DC-3.

The Collins 51R Navigation System includes a 280 channel receiver covering 108 mc to 136 mc in 100 kc steps and provides facilities for the following:

a. Localizers, tone type (90/150 cycles), including flag alarm.

b. Localizer, phase type, including flag alarm.

c. Omnidirectional ranges, indicating on cross pointer meter, course chosen by manual course selector. Includes operation of ambiguity indicator and flag alarm.

d. Omnidirectional ranges which, when automatically combined with magnetic heading information, provide automatic direction finding type of presentation in the cockpit.

The receiver utilizes the exclusive Collins Drift Cancelled Oscillator (DCO) circuit which provides extremely high stability and rejection of spurious signals. Two or more receivers can be operated with a single antenna.

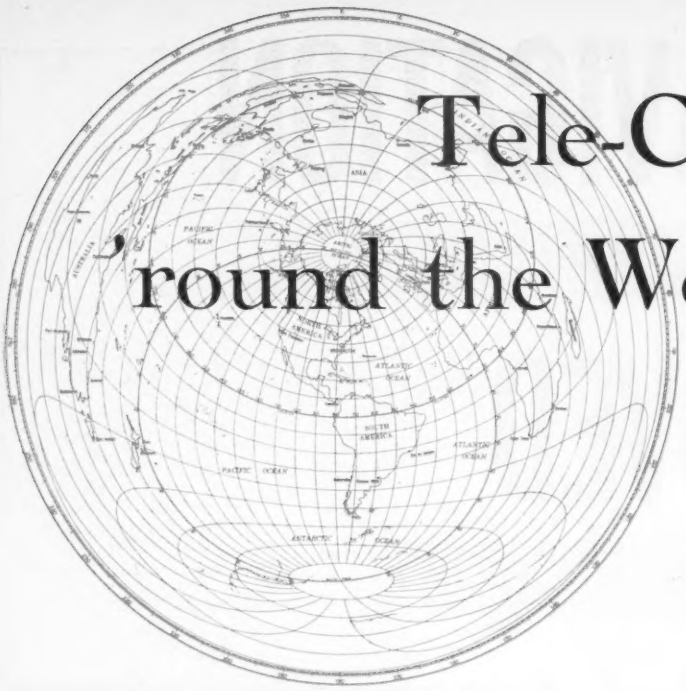
These successful demonstrations are historic because they mark the first major step in the development of a complete, fully integrated system which will permit guided and controlled flight in any direction, on any track, to any point within the coverage of the basic radio facilities.

IN RADIO COMMUNICATIONS, IT'S . . .

COLLINS

COLLINS RADIO COMPANY, Cedar Rapids, Iowa

11 W. 42nd Street, New York 18, N. Y. 458 South Spring Street, Los Angeles 13, Calif.



Tele-Communicatious 'round the World

By ROLAND B. DAVIES,
Tele-Tech Washington Bureau

News of engineering matters of importance and of markets in various foreign fields

FINLAND'S RADIO RECEIVERS INCREASE 17,000 IN YEAR—From preliminary statistical information gathered by the Finnish Postal and Telegraph Administration, it was revealed recently that the number of home radio receiver licenses in that country now totals about 560,000. The figure represents an increase of 17,000 receivers over those in use in 1945.

CANADIAN POSTWAR RADIO DEVELOPMENTS — Included in its postwar development of shortwave radio broadcasting, the Canadian Broadcasting Corporation will increase power of its stations at Montreal, Winnipeg and Vancouver. The CBC has also placed an experimental diversity receiving station in operation at Vancouver to receive transmissions from Australia and New Zealand for rebroadcast over the Canadian system. Other new developments in construction consist of the completion this past year at Sackville, New Brunswick, of complete facilities for European, South African and South American shortwave service and at Montreal the CBC constructed its first postwar FM transmitter operating on 98.1 mc with 250 watts power. The Canadian service also plans for installation of additional FM transmitters at Montreal, Winnipeg and Vancouver.

NEW SET-UP AT SALONIKA, GREECE—A new radio broadcasting station with 2 kw power recently has been established at Salonika, Greece, by the Ethnikon Idrima Radiofonos (National Radio Institute). The station, to be known as Radio Salonika, will accept advertising, it was reported, but will be subsidized by the Greek government, since it is not expected to be self-supporting.

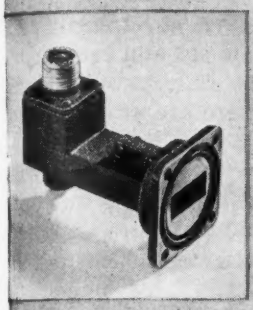
CHILE APPROVES MOBILE RADIO, POWER BOOSTS—Recent decrees of the government of Chile included authorization of a mobile radiotelephone system for the leading power utility, Empresa Nacional de Electridad, and approval of power increases, two shortwave stations and four standard broadcasting stations. The electric power organization will start operations with one land station and two mobile units. The broadcasting approvals were for the Sociedad Nacional de Agricultura to increase its Los Angeles station power from 1.2 to 10 kw; two 5 kw transmitters for Santiago shortwave operations of Corporacion Chilena de Broadcasting y Television; a second shortwave transmitter for the Sociedad Chilean Radiofusoria; three standard broadcasting stations under private ownership and a new standard station at Santiago for the government broadcasting and television corporation.

AUSTRALIA STARTING FM—First practical experiments on a large scale in the use of FM for broadcasting have been started in Australia. The work has been undertaken by engineers of the Postmaster General's Department, under instructions from the Federal Parliamentary Committee on broadcasting. The Australian experiments, it was said, are being projected to the time when medium wave channels in Australia are completely filled and it is then expected that the government-owned broadcasting system will swing to FM.

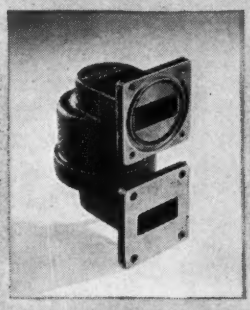
TO COOPERATE ON DISTRESS FREQUENCY—Three foreign governments — those of Russia, the Netherlands and Czechoslovakia—have agreed to cooperate with the United States in guarding the frequency of 8280 kc as an interim maritime and aeronautical distress channel until a decision on distress frequencies is reached at the coming World's Telecommunications Conference. Also, the radio station at the Schiphal Airport at Amsterdam, Holland, has arranged to receive possible calls on 8280 kc as long as there are aircraft using this frequency.

COLOMBIA SEEKING NEW TROPICAL FREQUENCIES — Colombian broadcasters are reported to be considerably aroused over the U. S. policy of advocating large power increases in the shortwave broadcasting field. They are charging that the FCC policy is revolutionary and are critical of the FCC advocacy of power of stations going as high as 750 kw on the ground that equipment is not available to Colombia to build even 50 kw sta-

EVERY DE MORNAY-BUDD WAVE GUIDE
is Electrically Tested, Calibrated and Tagged

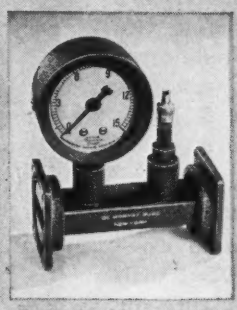


Crystal Mount DB-453

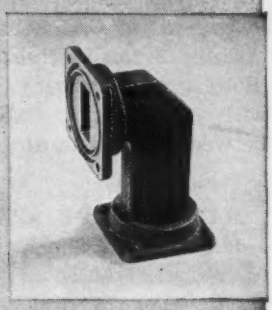


Rotating Joint DB-446

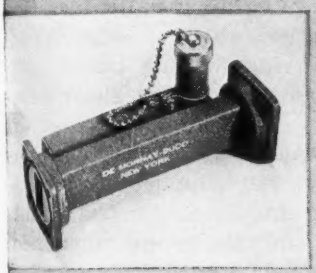
90° Elbow (H Plane) DB-433



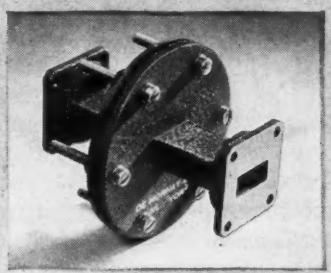
Pressurizing Unit DB-452



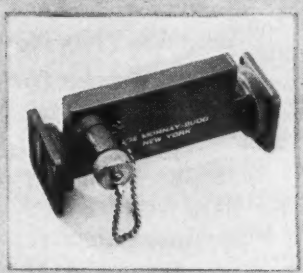
Mitered Elbow (H Plane) DB-43



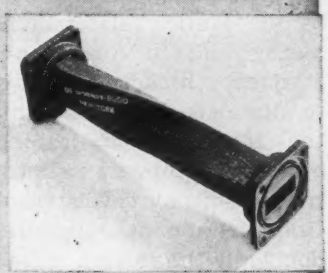
Uni-directional Broad Band Coupler DB-442



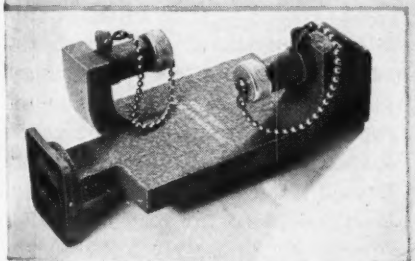
Bulkhead Flange DB-451



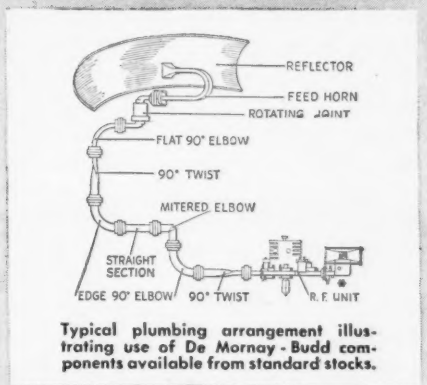
Uni-directional Narrow Band Coupler DB-440



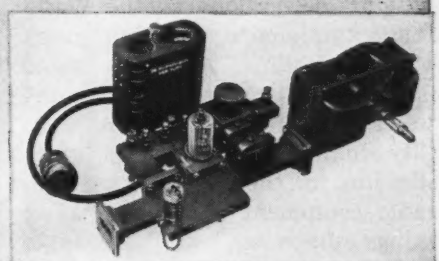
90° Twist DB-435



Bi-directional Narrow Band Coupler DB-441



Typical plumbing arrangement illustrating use of De Mornay - Budd components available from standard stocks.



RF Radar Assembly DB-412

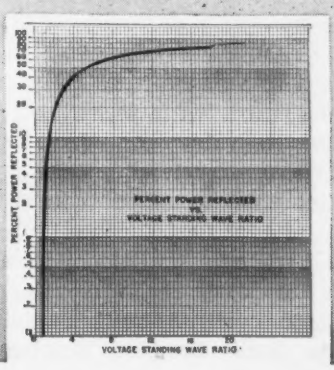
When you use any De Mornay·Budd wave guide assembly, you know exactly how each component will function electrically. You avoid possible losses in operating efficiency through impedance mismatches, or breakdown and arcing caused by a high standing wave ratio. (See chart below.)

De Mornay·Budd wave guides are manufactured from special precision tubing, and to the most stringent mechanical specifications. Rigid inspection and quality control insure optimum performance.

NOTE: Write for complete catalog of De Mornay·Budd Standard Components and Standard Bench Test Equipment. Be sure to have a copy in your reference files. Write for it today.

The curve shows the manner in which the reflected power increases with an increase in the voltage standing wave ratio. The curve is calculated from the following equation:

$$\% \text{ Power Reflected} = \left(\frac{\left(\frac{V_{max}}{V_{min}}\right) - 1}{\left(\frac{V_{max}}{V_{min}}\right) + 1} \right)^2$$



DE MORNAY BUDD

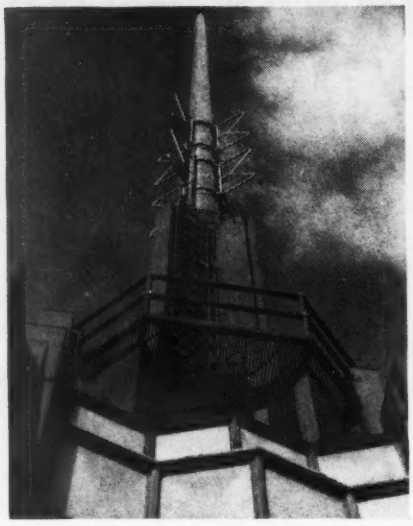
EQUIPMENT FOR 97% OF ALL RADAR SETS

De Mornay-Budd, Inc., 475 Grand Concourse, New York 51, N. Y.

tions. Two interesting radiocommunications developments have recently occurred in Columbia: 1. The Texas Petroleum Co. was granted permission to build a 1 kw radiotelephone station to serve its field camps with the proviso that it will turn over the equipment after 5 years. 2. TACA, South American airline, is considering a public radiotelegraph service to compete with All America Cables & Radio between Colombia and Peru.

MAY PROVIDE SPRINGBOARD—The coming World Radio Conference at Atlantic City, which starts May 15 and will run for three months with sessions in July of the World Telecommunications parley and in August on High-Frequency broadcasting, is expected to stimulate greatly the interest of the thousands of leading radio officials of foreign nations in the radio-electronic developments of the United States manufacturers. Undoubtedly the foreign radio officials and experts, who will make their nations' delegations at the World Radio Conference, will tour many of the leading American radio manufacturing plants and laboratories. It is felt that the Atlantic City conferences will be a great stimulus for the exporting of U. S. radio equipment and products. As things shape up now, the most fertile radio markets abroad are Latin America, the Far East and Africa in that order; Europe looms at present of lesser importance because of the competition from European manufacturers.

LATIN AMERICAN RECEIVER MARKETS—Practices followed by the U. S. industry in the next year or two will set the pattern for the future on the exportation of American receivers. But fine opportunities are offered in the Latin American republics where receiver markets, in general, are undeveloped. Before the war the United States was the principal supplier of receiving sets and the U. S. Commerce Department has prepared an estimated Latin American demand for the current year with a total number of 711,175 sets valued at $16,921,000. Brazil is the leading market prospect with an outlook of 199,000 sets, with an estimated value of $5,970,000; next is Mexico—where President Truman has so enhanced the amity with this country by his visit—which is estimated to have a demand for 160,000 sets valued at $4 million; Chile comes third with 94,000 sets and $1,500,000 value; fourth is Cuba with 60,000 receivers and $1,200,000 value; then Colombia with 55,000 sets and $1,100,000; and Panama and Venezuela both loom as markets for 20,000 receivers valued at $500,000 each. Argentina, Bolivia, Costa Rica, Ecuador, Guatemala, Peru and Uruguay are all estimated to provide sales of sets from $150,000 value to $400,000.



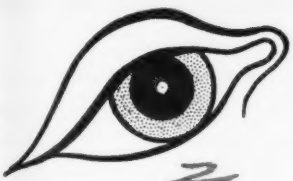
WGYN's New Batwing Antenna for FM-TV

Looming up against the horizon like a futuristic atomic gun or a rocket poised for flight into space, WGYN's new superturnstile "batwing RCA antenna" is now in use. Consisting of eight double-fed elements fastened to the stainless steel flagpole atop the world's third tallest building, 70 Pine Street, New York City, this new antenna is designed to carry television and facsimile transmission simultaneously with WGYN's regular scheduled FM programs. The antenna is the first of its kind. It gives a power gain of 2.2, producing the equivalent of 20,000 watts at 500 ft., new FCC standard for class B metropolitan FM stations. Height of antenna above the sea-level is 950 ft. The antenna is equipped with heating elements to eliminate the formation of ice. The signal will cover an area of approximately 9,000 sq. miles.

PHILIPPINES MAY BECOME GOOD MARKET—Havoc of Japanese occupation is now being cleaned up by the new Republic of the Philippines government and so far the radio set and equipment market is not fully determinable. At present, there are an estimated 50,000 to 75,000 sets in the Philippines, mainly supplied by American manufacturers before the war and U. S. manufacturers are expected to resume their top place in this market. Five new 1 kw broadcasting stations are being projected by the new Philippine Broadcasting Corporation, which already is operating in Manila and plans additional stations in Cebu, Iloilo, Zamboanaga, Tacloben and Davao, the latter stations to go on the air July 1. Raytheon supplied the transmitting equipment for the Manila station and may be the supplier for the five new transmitters.

BRITISH EXPORT PRODUCTION BIG—Even though the harsh winter and impact of the coal and power shortage undoubtedly will reduce 1947 production of receivers and transmitter equipment in the United Kingdom, this year's output is expected to far exceed the 1946 production of nearly 1,500,000 sets, according to statistics of the Department of Commerce's Office of International Trade. As a result of intensified production, there is little prospect that American products will share that market and both during this year and in 1948 the British radio industry is bending every effort to export its products, even though the British demand for receivers at present exceeds the supply. American products also face a hurdle in entering the British market because of the British Radio Patent Pool, made up of such leading English manufacturers as EMI, Thomson-Houston Co., Ltd., Marconi, Philips, General Electric Ltd., and A. C. Cossor Ltd., which "exercises a restraining influence over the importation of radio and radio parts." The principal outlet for American radio components is in the maintenance of the fairly large number of U. S. receivers in the United Kingdom.

See what your ears miss!



SHERRON
R.F. NULL
DETECTOR

Noise can't interfere with the indications registered on this new Sherron instrument. Where din and hubbub would nullify aural manifestations, you can count on the visual features of Model SE-518 to provide the findings, clearly, unmistakably. Instantaneously responsive to changes of signal level, the R. F. Null Detector is equipped with a Cathode Ray indicator . . . As a signal generator to provide power at 1 MC, the Sherron R. F. Null Detector is invaluable. It also serves as a sensitive detector at the same frequency. Both generator and detector are housed in the same cabinet.

Frequency: 1 MC

Generator Output: 0-5 volts

Detector Gain: 500,000 plus

Harmonic Suppression: 2nd down more than 100 db

Power Requirements: 115 volts, 60 cycles, 120 watts

Model SE-518

SHERRON ELECTRONICS CO.
Division of Sherron Metallic Corporation
1201 FLUSHING AVENUE • BROOKLYN 6, NEW YORK

WASHINGTON

Latest Electronic News Developments Summarized by Tele-Tech's Washington Bureau

BIG EXPENDITURES FOR AVIATION RADIO—Furore over succession of aviation accidents this winter has had its silver lining in expediting the programs of the air transport industry and government agency specially concerned with flying safety, the Civil Aeronautics Administration, to install larger amounts of radio-electronics communications and navigation aids and systems. There has raged a feud in Congressional hearings over Instrument Landing System (ILS) and Ground Control Approach (GCA), but out of the controversy has arisen a sensible approach toward combining all present radio-electronic systems in the most useful devices until newer systems, like Teleran, Navar, Lanac, etc., are more fully tested. Considerable sums are planned for expenditures—the Senate Interstate Commerce Commission recommended that the CAA divert some $45 million already allocated for additional and new small-city airports to install navigational aids in the existing airports. The Air Transport Association has proposed to the airlines that they should spend nearly $7 million for immediate installation of ILS and GCA in 25 major airports.

SHAPING OF TV CHANNELS FOR MOBILE SERVICES—Because of the crowded condition of the radio spectrum and the huge growth of mobile radiotelephone service, including public telephone service between aircraft and the ground, the FCC is studying a plan of sharing the mobile channels with television. The plan would be for the urban mobile service in one city to utilize the television channel assigned to another city and vice versa. Experimental operation of this service, including calls from aircraft, recently was undertaken by the A. T. & T. and Bell Telephone Laboratories. Microwaves also are being tested for these services to relieve the congestion of the spectrum.

SHORTWAVE BROADCASTING—"Flop" of the State Department's broadcasts to Russia, which showed up the paucity of the audience, has cooled the ardor of the proponents of great expansion of shortwave broadcasting and certainly Congress will be more anxious than ever to slash the budget of the State Department for this radio field. If shortwave broadcasting is set back in this country by the Congressional economy axe and by the failures in the current operations, it will have an effect on the U. S. delegation at the coming World Radio and High Frequency Conferences in Atlantic City in opposing too large allocations of spectrum space for shortwave broadcasting. This will strengthen the hand of the aviation and communications services which are likewise emphatically unfavorable to large slices of frequencies being assigned to high frequency broadcasting.

WORLD RADIO CONFERENCE—Proposals of the United States, formulated by a joint industry-government preparatory committee after months of study, have been transmitted to the Berne Bureau of International Telecommunications and will be circulated from the Swiss capital to the 60 nations which have been invited to the Atlantic City conference. The American delegation is suggesting the establishment of a permanent International Telecommunications Union which probably would become a part of the United Nations, but undoubtedly Great Britain and France will oppose the move of such an organization from Switzerland to the United States. Another U. S. proposal is for the establishment of a Central Frequency Registration Bureau which would function with greater speed than the present Berne Bureau. In order to utilize the spectrum to greatest advantage, the U. S. proposals also are suggesting sharing of shortwave broadcasting bands by different nations at specified hours.

TELEVISION DECISION BY FCC TO GIVE IMPETUS—While the Commission's decision on color TV was not available at our press deadline, best guesses were that the FCC would go along largely with the views of the special RTPB panels—color television still requires additional development and field testing for public service. Best concession for CBS position was thought to be FCC advocacy of intensified color television experimentation and possibly semi-public operation of color telecasting in the upper bands.

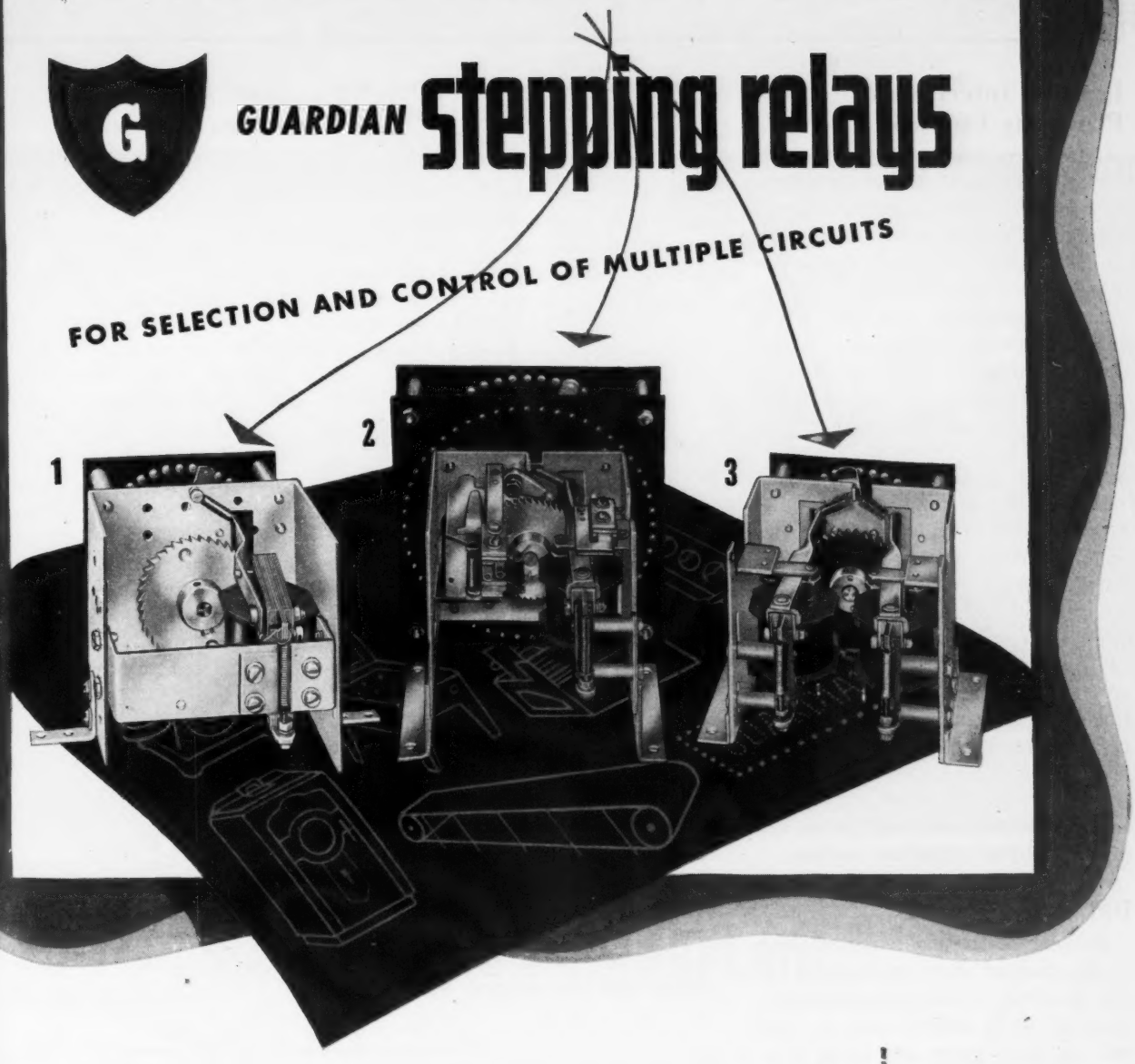
FM NOW BIG BUSINESS—Forecasts by FM Association to *Tele-Tech* are that 1947 sales of FM broadcast home receivers will aggregate between $300 and $400 million with good possibility of lower-priced sets, perhaps some console models, reaching the market this summer. In addition, sales of transmitters will total another $50 million with over 700 FM stations likely to be on the air before the end of this year. Two commercial FM networks also are in the making, now in the discussion stage.

National Press Building
Washington, D. C.

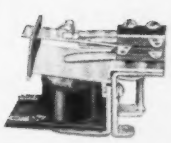
ROLAND C. DAVIES
Washington Editor

GUARDIAN stepping relays

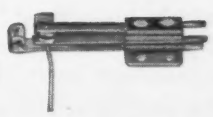
FOR SELECTION AND CONTROL OF MULTIPLE CIRCUITS



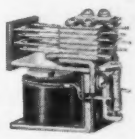
This trio of *standard* Guardian Stepping Relays: (1) continuous rotation, (2) electrical reset, (3) add and subtract—will start you off with a minimum of design and keep your product operating indefinitely. The Guardian Steppers shown are adaptable to numerous applications: automatic circuit selection; automatic sequence selection of circuits; automatic sequence cross-connection of circuits. They are used in automatic business machines, production totalizers, conveyor controls, animated displays, telephony, remote tuning, with a host of additional uses you will soon discover. On each, the contact finger rotates counter-clockwise. All three Steppers follow 10 pulses per second within the rated voltage range of the relay. Special construction prohibits skipping or improper indexing of the ratchet. Available in separate units or in combination with relays, contact switches, solenoids; completely assembled and wired to terminals; mounted on special bases or in enclosures. "Special" modifications are obtainable in production quantities. Write for Bulletin SR.



Series 100 Snap-Action Relay



Guardian Featherub Switch



Series 500 Midget Relay

Series 1-A Solenoid

GUARDIAN ELECTRIC

1622-D W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

News of the Industry

Ignition Interference Problems Tackled

After two years of intensive work looking to the elimination of interference to broadcasting and communications services by automobile ignition noise, the joint committee representing the Society of Automotive Engineers and the Radio Manufacturers Association has decided what to do about it. First, it has been decided that emission from ignition systems can be kept below 35 microvolts per meter at 50 feet, or 15 mv below the 50-mv minimum for FM and substantially below the 500 mv minimum for television; second, it was decided that this desirable result could be accomplished by using 10,000-ohm suppressors at spark plugs and distributor, by locating ignition coils so that leads may be shortened to not over eight inches, and by keeping primary wiring, metal rods and conductive tubing away from high tension wiring. In other words they would restrict the radiation range of the vehicle's ignition system.

RMA Surveys FM

Because of the existence of some dissatisfaction over production of FM receivers, Radio Manufacturers Association is setting out to find out just how many are being produced and by whom. RMA board of directors authorized appointment of a committee, headed by Philco's vice-president L. F. Hardy to prepare a factual report, and to confer with the recently organized FM Association. It is planned for the report to cover both quantity and quality of receivers. Coincidentally, RMA launched its $50,000 promotion campaign, "Radio-in-every room." RMA membership is at a new peak, 346 companies, as compared with 104 in '39-40.

Electronic Color TV

Backed by patents (2,389,646 and 2,389,645) issued in August 1942, Geo. E. Sleeper, Jr., has designed an all-electronic color television system for Color Television, Inc., San Francisco. The system is described as being similar to the Thomascolor method in which three images, filtered to correspond to three primary colors, are broadcast simultaneously and when received are superimposed to re-create the color. Sleeper was formerly connected with Farnsworth Television and Radio Corp. and the Columbia Broadcasting System.

500 Hours of Coaxial TV

That AT&T coaxial cable between New York and Washington saw much service during 1946. It was used 188 times and carried over 500 hours of television pictures. Similar cables are being put in at the rate of 3000 miles a year, in a few years will have reached 12,000 route miles.

Electron's Birthday

The British Institute of Physics plans to mark the 50th anniversary of the discovery of the electron by Sir Joseph Thomson with an exhibition, preceded by a series of meetings to be held in London starting Sept. 25. The exhibition, open to the public, will run several weeks.

State Department Alters Allocations

The Department of State has decided on frequency allocation recommendations to be made to the Bureau of the International Telecommunications Union. These involve some proposed changes from the allocation plan covering the 25,000 to 30,000,000 kc spectrum adopted last September, and from the table of proposed service allocations below 25,000 kc adopted about a week later. Proposed changes result from a general review of service allocations from 10 kc to 20,000 mc by the preparatory committee for the forthcoming International Tele-communications Conference to be held in Atlantic City starting May 15. Summarized, the proposed changes are:

1—A band has been added to the navigational service, between 10 and 14 kc.

2—Coastal telegraph stations are permitted in the band 14-100 kc.

3—The band 200-280 kc has been designated for long distance aid.

4—The Loran allocation betwen 1800 and 2000 kc has been better defined and the degree of sharing possible on a non-interfering basis indicated.

5—Extent to which the US intends use of 4000kc for tropical broadcasting is indicated.

6—Aeronautical mobile route band 16,490-16,540 kc has been shifted to 15,300-15,350 kc.

7—Aeronautical route band 17,980-18,040 kc would be shared by aeronautical fixed services.

(*Continued on page* 117)

CONVENTIONS AND MEETINGS AHEAD

Mar. 31-Apr. 2—Midwest Power Conference—Palmer House, Chicago.

Apr. 14-18—Radio Broadcast Engineering Institute—Sponsored by the Georgia Assn. of Broadcasters and the Georgia Chapter of IRE in cooperation with the Georgia School of Technology, Atlanta, Ga.

Apr. 19—Chicago IRE Conference—Northwestern Technological Institute, Chicago, Ill.

Apr. 21-25—Society of Motion Picture Engineers — 61st Semi-annual Convention, Drake Hotel, Chicago, Ill.

Apr. 28 (and following two weeks)—International Meeting on Marine Radio Aids to Navigation (IMMRAN) — New York City and New London, Conn., by U.S. Dept. of State. Chairman, Dr. W. L. Everitt, Univ. of Illinois, Urbana, Ill.

Apr. 28-30—RMA (Engineering Dept.) Spring Meeting—Hotel Syracuse, Syracuse, N. Y.

May 3—Cincinnati Section of the Institute of Radio Engineers—Technical conference featuring television, Cincinnati, Ohio. E. J. Bussard, Crosley Corp., 1729 Arlington, Cincinnati.

May 4-8—National Electrical Wholesalers Assn.—38th Annual Convention, Hotel Traymore, Atlantic City, N. J.

May 5-7 — International Scientific Radio Union (American Section) and Institute of Radio Engineers—Joint meeting, Washington, D. C.

May 6-10—Society of the Plastics Industry—Annual Convention (Stevens Hotel) and National Plastics Exposition (Coliseum), Chicago.

May 13-16—Radio Parts and Electronic Equipment Conference and Show—Stevens Hotel, Chicago.

May 15—World Telecommunications Conference—Ambassador Hotel, Atlantic City, N. J.

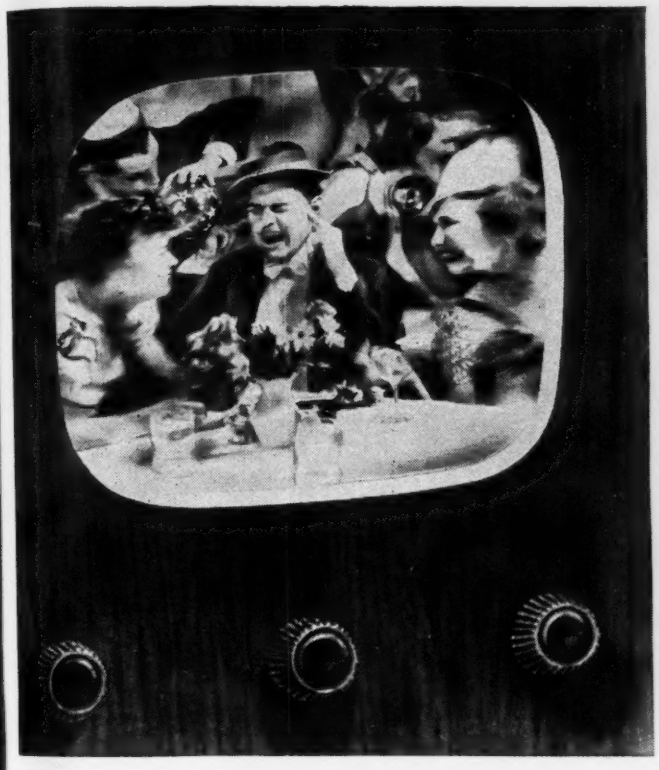
May 17—Institute of Radio Engineers, North Atlantic Region—Radio engineering meeting, Hotel Continental, Cambridge, Mass. John M. Clayton, General Radio Co., Cambridge.

June 7—Institute of Radio Engineers—Annual Conn. Valley Section meeting. Half-day session on FM receivers.

June 16-20—American Society for Testing Materials—Annual (15th) Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

Sept. 8-12—Second National Instrument Conference and Exhibit—Hotel Stevens, Chicago.

CONFUSING? OR AMUSING?

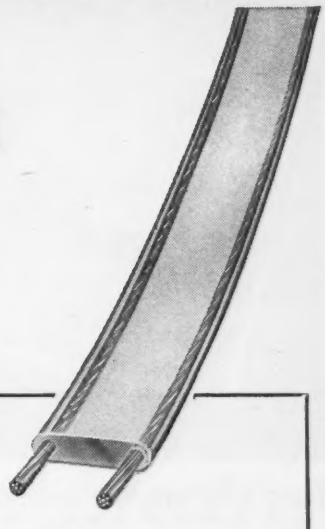


Lead-In Lines Play an Important Part in Television Reception

The effects of attenuation and impedance mismatch on FM and Television reception are minimized by Anaconda Type ATV* lead-in lines.

The satin-smooth polyethylene insulation of Type ATV line sheds water readily, thus avoiding subsequent impedance discontinuities. This material also has exceptionally high resistance to corrosion. Count on Anaconda to solve your high-frequency transmission problems—with anything from a new-type lead-in line to the latest development in coaxial cables. 47439

*An Anaconda Trade-Mark



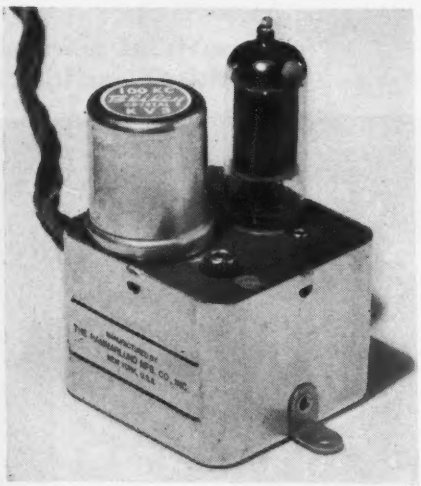
A Type ATV Lead-In for Every Need

Anaconda offers a complete selection of Type ATV lead-in lines for 75, 125, 150 and 300 ohms impedance unshielded and 150 ohms shielded. For an electrical and physical characteristics bulletin, write to Anaconda Wire and Cable Company, 25 Broadway, New York 4, N. Y.

ANACONDA

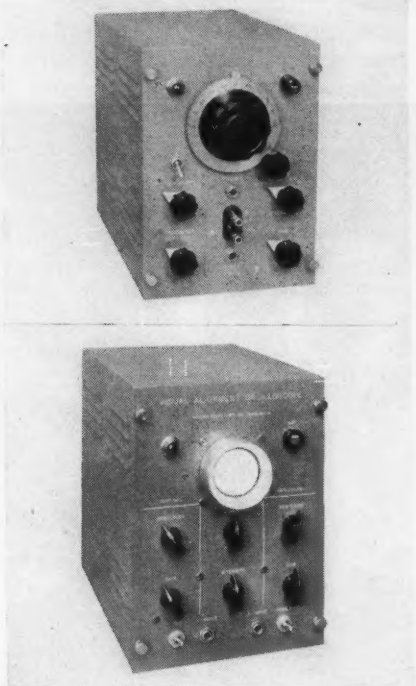
ANACONDA WIRE AND CABLE COMPANY

New Lab and Test Equipment



FREQUENCY STANDARD

Small enough to fit into almost any receiver the FS-135-C frequency standard will serve as an accurate frequency meter by generating marker signals every 100 kc over the entire range of the receiver. It consists of an oscillator circuit using a 6AK6 type tube and a special spring-suspended 100 kc crystal, the frequency of which may be adjusted to zero beat with WWV. By means of this adjustment the unit has practically the same accuracy as a primary frequency standard. — *Hammarlund Mfg. Co., 460 W. 34 St., New York 1.*

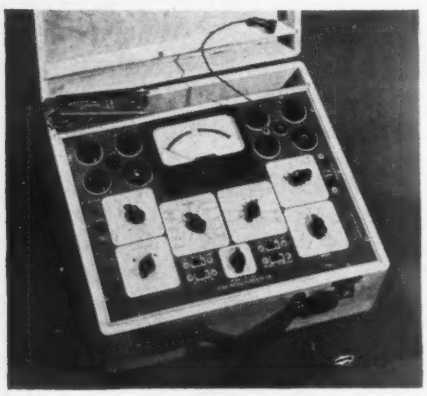


ALIGNMENT INSTRUMENTS

Intended for precision visual alignment of IF and tuned coupled circuits in the range of 20 to 500 kc, 204 TS low frequency signal generator has a linear sweep deviation adjustable from 0 to 70 kc peak to peak. It may be used in conjunction with model 188 TS oscilloscope, which has simplified circuits for visual alignment use. The scope has the usual focus, intensity and centering controls, as well as vertical and horizontal amplifiers, but is not provided with internal sweep circuits. Both instruments operate from 110 volts, 50-60 cycles, ac. — *Harvey Radio Laboratories, Inc., 439 Concord Ave., Cambridge 38, Mass.*

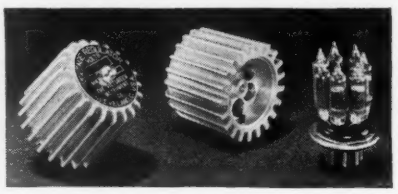
HIGH VACUUM GAGE

Designed for continuous high vacuum production lines or laboratory applications, the Skanascope vacuum monitor indicates the amount of evacuation through color patterns on a fluorescent screen instead of a meter. The instrument monitors the total pressure of permanent and condensable gases in a system and compensates for the effect of temperature changes on the pressure. It is automatic, needs no calibration and operates on the standard 115 v., 60 cycle, ac supply. Color indication is given in five stages down to a pressure of 30 microns for air.—*Distillation Products, Inc., 755 Ridge Road West, Rochester 13, N. Y.*



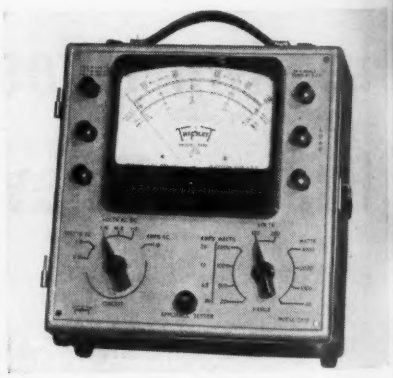
TUBE AND CIRCUIT TESTER

Model MT-12 combination tube and set tester has provisions for checking 450 types of radio tubes. Sections of multi-purpose tubes are tested individually, and tube noise and capacitor leakage also may be made. The multitester section of the instrument is equipped with 27 ranges of voltage, current, and resistance measurements. A wood cabinet with removable cover houses the instrument and provides storage space for line cords, test leads, etc.—*Star Measurement Co., 442 East 166 St., New York 56.*



VOLTAGE REGULATOR

Containing seven subminiature gaseous voltage regulator tubes arranged circumferentially and housed in an aluminum casting with octal base, model 348 voltage regulator unit offers close regulation within 0.5 volt and is stable over long periods of time. It is suitable for many applications where space is at a premium. Individual tubes are available separately with nominal voltage of 129 to 134 volts. —*Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.*



CIRCUIT ANALYZER

Wattage consumption, current and line voltage of appliances and small motors may be measured under operating conditions with model 2470 appliance tester, which is provided with double-primary transformers and "Y" box resistors for accurate testing on lines with unbalanced currents or voltages. The instrument has five ac watt scales from 0-4,000 watts at 130 or 260 volts, four ac current ranges from 0-26 amps., and two ac-dc volt ranges from 0-130-260 volts.—*Triplett Electrical Instrument Co., Bluffton, O.*

Send for this helpful Data Book on tubes by

Western Electric

In concise, tabular form, this new book gives the essential data on 166 codes of electron tubes designed by Bell Laboratories and made by Western Electric. Planned to help the circuit designer quickly find the tube best suited to his needs, it contains technical characteristics, ratings, dimensions and 89 basing diagrams—all arranged for quick, easy reference. Send the coupon for your copy today!

T-4

Graybar Electric Co.,
420 Lexington Ave., New York 17, N. Y.

Please send me the General Bulletin on Western Electric electron tubes.

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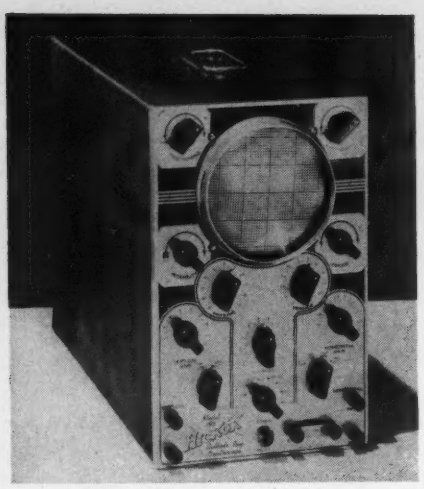
—QUALITY COUNTS—



GENERAL PURPOSE 'SCOPE

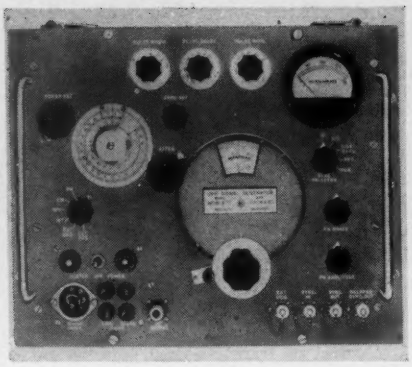
Designed for visual analysis of waveshapes of television, FM, and AM signals, model 195 oscillograph has a high gain vertical amplifier providing a deflection of 1 in. for .05 volt input. The instrument, using a 5UP-1 5-in. cathode-ray tube, has a sinusoidal sweep circuit and is equipped with phasing control for IF, rf, and discriminator alignment. — *Hickok Electrical Instrument Co.*, 10606 *Dupont Ave., Cleveland* 8, *Ohio.*

KILOVOLTMETER

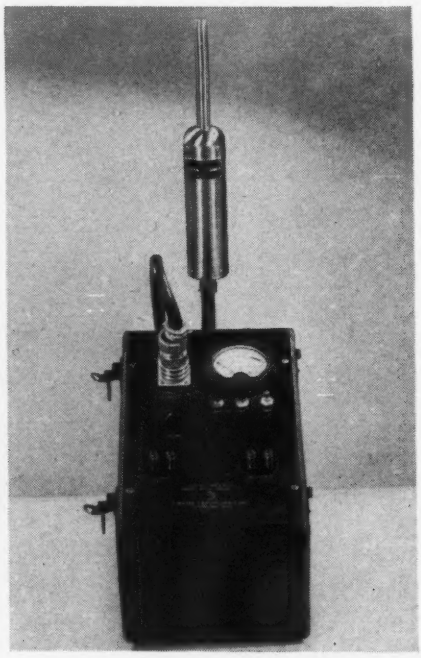
Specifically adapted for measurements in television and similar applications, this series of high sensitivity kilovoltmeters is available in eight models to provide dc and ac-dc types in any required voltage combination. Accuracy of the units is 2% for dc and 5% for ac measurements. A typical unit, model 760-A, has three scales of 5, 10, and 20 KV with a sensitivity of 10,000 ohms per volt and is provided with a polarity reversing switch. The instruments are portable. — *Shallcross Mfg. Co., Collingdale, Pa.*

UHF SIGNAL GENERATOR

Providing direct-reading frequency and voltage scales, CW, FM, pulsed or delayed pulse output in one compact unit model 616A UHF signal generator is a wide-band laboratory standard for use in the frequency range between 1,800 and

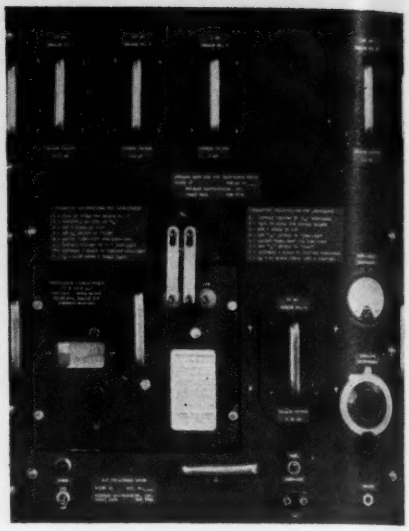


4,000 mc. Utilizing a resonant-cavity, reflex klystron oscillator, rf output from the unit may be read in microvolts or db from 0.1 microvolt to 0.1 volt. No voltage adjustments are necessary, when changing frequency. Accuracy of frequency calibration is within ± 1% and stability is of the order of 0.005% per degree centigrade in ambient temperature. Internal pulsing may be synchronized with external pulses or delayed from 3 to 300 microseconds.—*Hewlett-Packard Co., Palo Alto, Calif.*



SOUND PRESSURE INSTRUMENT

Any type of absolute sound pressure measurement over the entire audible and early ultrasonic range up to 40 kc can be made with model GA-1002 sound pressure measurement system which includes model M-101 standard microphone, a pre-amplifier with 15 ft. cable, and a battery-operated auxiliary amplifier. A conventional electronic voltmeter can be used for direct reading of sound pressure. The dynamic range extends from less than 1 dyne/cm^2 to 20,000 dynes/cm^2 (160 db) without distortion. The instrument, though serving as a laboratory standard, is rugged enough to measure shock pressures generated by explosions.—*Massa Laboratories, Inc.*, 3868 *Carnegie Ave., Cleveland* 15, *Ohio.*

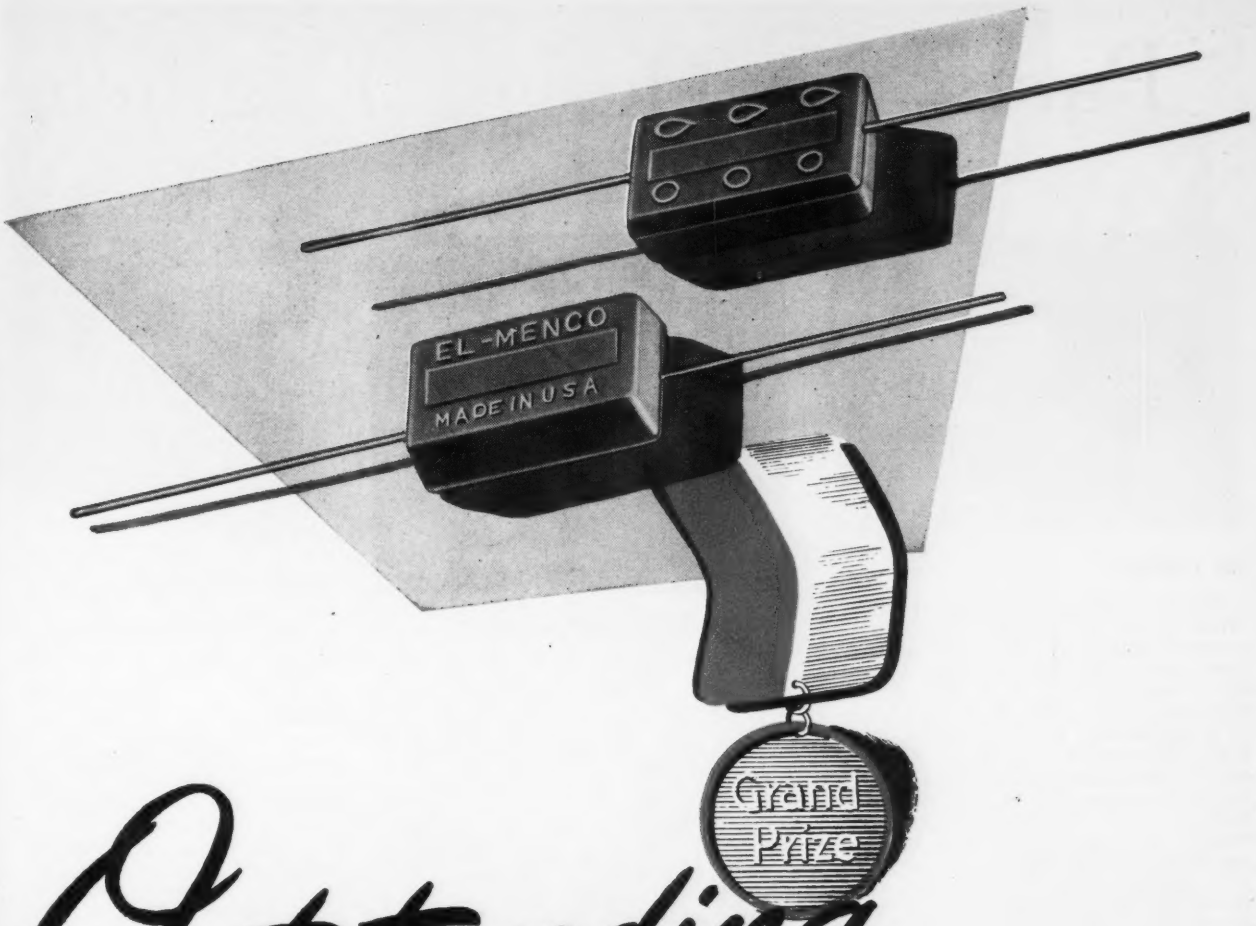


INDUCTANCE-CAPACITANCE METER

Using a capacitance - difference method of measuring inductance and capacitance, Model 10, rf inductance meter has a range of 1 μh to 100 μh and 0-1,000 mmfd. Test frequencies from 11 to 1,600 kc are generated by two oscillators which are initially adjusted to the same frequency. The detuning of one oscillator by the unknown inductance or capacitance is then measured. Inductance of capacitance is given by the difference between two settings of the standard variable capacitor. Five pairs of plug-in coils provide overlapping decade ranges of test frequency for both oscillators. A meter gives indication of zero beat adjustments to within ±1 cycle, permitting measurement of the unknown component to within about ±1%.—*Wheeler Laboratories, Inc.*, 259-09 *Northern Blvd., Great Neck, N. Y.*

SWEEP OSCILLATOR

Suitable for testing and alignment of FM and television receivers, Mega-Sweep Jr. sweep oscillator test unit utilizes two klystrons to provide a 30 mc sweep over the entire frequency spectrum of 400 kc to 500 mc. If required, output frequency can be extended to 1000 mc. Output frequency is measured by means of a microwave wavemeter, calibrated up to 900 mc, which covers the range without switching. The unit, weighing 20 lb., has a self-contained power supply and operates on 117 volts, 60 cycle, ac.—*Kay Electric Co., East Orange, N. J.*



Outstanding

El-Menco CAPACITORS are known and recognized for their high quality and absolute dependability throughout the entire field of electronic equipment manufacturing.

Constantly improved to meet changing standards, El-Menco Capacitors can be installed with the certain knowledge that they are the latest and best development in the capacitor industry. Electronic equipment manufacturers are invited to write for a new catalog.

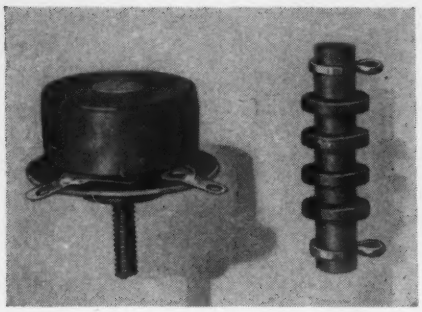
THE ELECTRO MOTIVE MANUFACTURING CO., INC.
Willimantic, Connecticut

ARMY NAVY

Foreign Radio and Electronic Manufacturers communicate direct with our Export Department at Willimantic, Conn. for information.

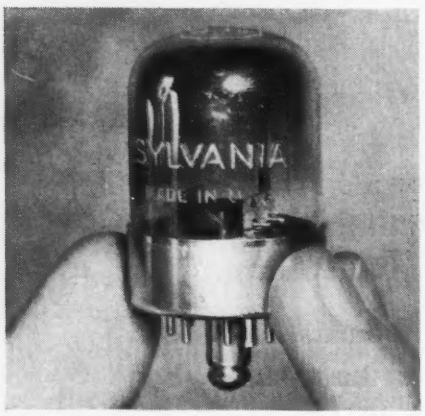
MOLDED MICA **El-Menco** MICA TRIMMER
CAPACITORS

Parts for Design Engineers



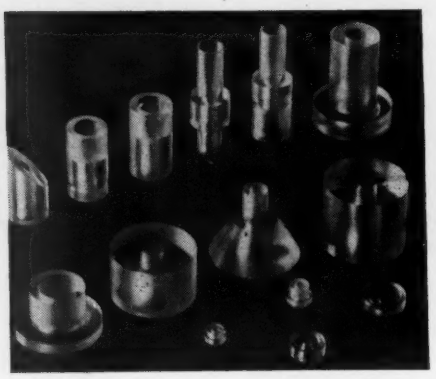
RF CHOKES

Available in eight standard values from 2.5 to 125 millihenries with a current rating of 125 ma, type LHC iron core rf choke has high Q, low dc resistance and low distributed capacity. It is mounted by means of a single 6-32 threaded stud. Type LAB pie-wound rf chokes have a maximum allowable current of 125 ma and are wound on PBE phenolic forms. Four values are available, wound with four pies, from .75 to 5 millihenries. Wound with six pies the chokes are available in four ratings from 7.5 to 15 millihenries.—*Cambridge Thermionic Corp., Dept. 5, 445 Concord Ave., Cambridge 38, Mass.*



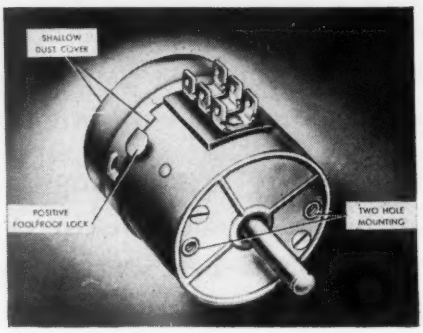
UHF DOUBLE TRIODES

Permitting space saving and reduction of tubes required for cascade amplifiers in television and FM applications at frequencies up to 400 mc, these two new high mutual conductance double triodes have independent elements with the exception of heaters. Type 7F8 is supplied with a 6.3 volt, 0.3 amp. heater, while type 14F8 requires 12.6 volts at 0.15 amps. from ac or dc source. Typical operating conditions for both types are: plate voltage, 250 with a plate current of 6 ma, and maximum grid circuit resistance of ½ megohm. Mutual conductance is 3,300 μmhos, and amplification factor is 48.—*Radio Tube Div., Sylvania Electric Prods., 500 Fifth Ave., New York 18.*



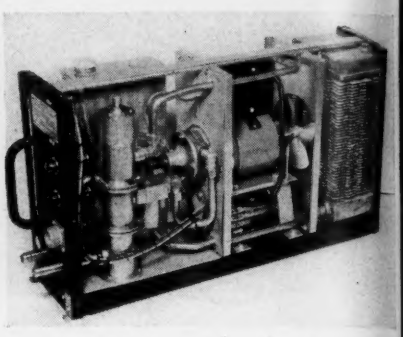
UHF INSULATING MATERIAL

Suitable for use in connectors, stand-off insulators, uhf antenna and oscillator coils and other uhf insulating applications as well as in the manufacturing of television, fm, and radar sets, the new Textolite No. 1422 insulating materials have a power factor of .0006 to .0009 at 3000 mc with a dielectric constant of 2.4 to 2.5. Adaptable to automatic and semi-automatic fabricating equipment the material can be machined to close tolerances and has unusual heat resistance, maintaining its shape up to 200° C. Recommended where compression and injection molded plastics are not suitable because of close tolerances, Textolite has a tensile strength of approx. 10,000 lbs/sq. in. and a spec. gravity of 1.05.—*Chemical Dept., General Electric Co., Pittsfield, Mass.*



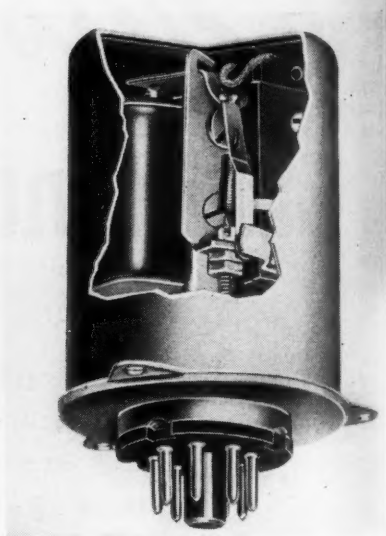
IMPROVED ATTENUATORS

A new type of mechanical construction in the present line of Daven attenuators has resulted in the following improvements: 50% less space is required to remove the dust cover, thus permitting smaller mounting space; fibre and moisture absorbing parts have been eliminated; good electrical contact is assured between front of unit and back cover; a two-piece non-ferrous can with a foolproof lock is constructed to permit the dust cover to be removed with one hand. Two hole mounting is standard on these new type units.—*Daven Co., 191 Central Ave., Newark, N. J.*



HEAT TRANSFER UNIT

Equipped with a four-bank radiator, cooling fan, circulating pump, reservoir, flowswitch and thermostat, Model 1 heat transfer unit will dissipate up to 1000 watts, when used in connection with television, radar, X-ray tubes, mercury lamps, induction heaters and similar high power equipment. The motor is 1/40 HP, 3450 rpm, 110 volt ac induction type, and pump and fan are both mounted on the motor shaft.—*Eastern Industries, Inc., New Haven 6, Conn.*



SENSITIVE RELAY

Hermetically sealed Bulletin 108 sensitive relay is a plug-in type mounted on a standard octal base and enclosed in a cylindrical metal can. The unit is provided with normally open single-pole contact having a contact rating of 2 amps. at 24 volts ac-dc, 0.75 amp. at 125 v. dc, and 2 amps. at 125 v. ac for non-inductive loads. With a coil consumption of 0.56 watt the relay is suitable for current sensitive applications from 1.3 ma to 0.54 amps on 0.1 to 48 volts dc.—*Ward Leonard Electric Co., Mount Vernon, N. Y.*

IN adjusting itself to its greatly expanded postwar volume Formica has arranged and installed an entirely new department for the production of tubing, much more spacious, with modern high production machinery arranged for the most efficient straight line output.

That means beginning *now* we can take care very promptly of your tubing orders, no matter how large. You can also be sure of uniformity and high quality.

Electrical characteristics of Formica tubing have been much improved by recent developments in resinoids and by production techniques that have been affected by knowledge gained by the many special problems the Formica engineering department was called upon to solve during the war.

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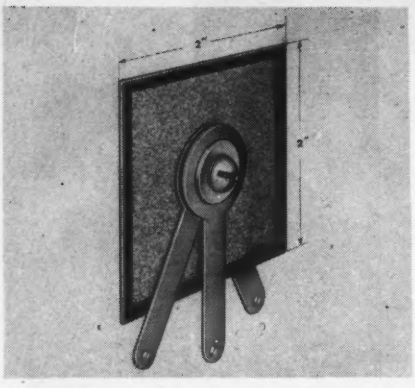
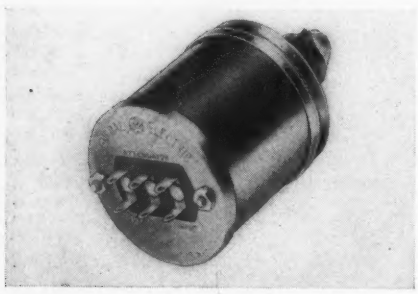
THE FORMICA INSULATION CO., 4657 SPRING GROVE AVENUE, CINCINNATI 32, OHIO



COPPER OXIDE RECTIFIER

Intended for portable radio low voltage battery charging, this permanent, full-wave copper oxide rectifier is light in weight, rugged and dependable. Rated at 1.5 amperes continuous current, its small 2-in. sq. size makes it adaptable to the limited space requirements of portable radios.—*Bradley Laboratories, Inc., 82 Meadow St., New Haven 10, Conn.*

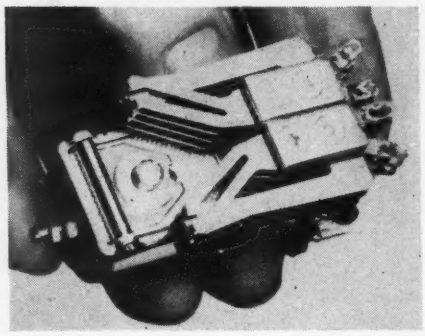


TEN WATT ATTENUATORS

Constant impedance attenuators with zero insertion loss, dissipating 10 watts power at any setting, have been added to a line of radio parts. Attenuation of the unit is linear up to 30 db in ten steps, beginning with zero and progressing in 3 db steps up to 24 db, followed by infinity. The resistance element is high-grade wire wound on a fiber glass core covered with fiber glass insulation.—*Specialty Div., General Electric Co., Wolf Street Plant, Syracuse, N. Y.*

NEON-GLOW VOLTMETER

Immune to mechanical and electrical abuse and virtually burn-out proof the Mini-Volt neon-glow device indicates ac or dc voltage and may be used for checking lines, blown fuses, leakage, plate voltages, etc. Calibrated for use on ac from 65 to 660 volts with an impedance of ½ megohm the device is operated by turning the control knob till the neon light extinguishes, the voltage being read off the scale. For dc the reading is multiplied by 1.15. The instrument is provided with 12 in. flexible test leads.—*Industrial Devices, Inc., Edgewater, N. J.*



DC RELAY

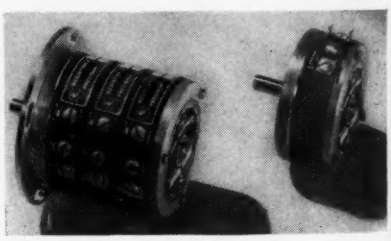
Designed for extremely fast operation at 1 to 2 milliseconds, the Clare type "J" dc relay combines features of the conventional telephone-type relay with the small size and light weight of aircraft relays. Independent twin contacts, made of palladium and rated at 4 amps., 150 watts, reduce the possibility of contact failure. A hinge type armature bearing provides largest possible bearing surface. The relay is available in single and double-arm types with a maximum of ten springs on a single arm, and 20 on a double arm relay.—*C. P. Clare Co., 4719 West Sunnyside Ave., Chicago 30, Ill.*

PRECISION LIMIT SWITCH

Designed for control circuit and pilot duty operation Amptrol precision limit switch has low actuating pressure of 1¾ oz. and a travel differential of .003 in. The switch is adequate for direct control of motors as large as ⅓ hp. rating. It is of the magnetic snap action type utilizing a spring load to overcome the pull of a permanent Alnico magnet. The unit is available in normally closed, single pole, single throw model only.—*Friez Instrument Div., Bendix Aviation Corp., Baltimore, Md.*

SOLDERING TOOL

Operating on the resistance heating principle, the new model Thermo-Grip soldering tool heats 20% faster, has a thumb switch for close heat control, is light weight, compact, portable, and can be used for long periods without overheating. Complete unit includes a transformer or power unit and soldering attachment which operates like a pair of pliers. Holding the work with the "Plier" tool completes the secondary circuit and causes instant local heating. Handles of the tool are of light-weight plastic. The unit is rated at 1000 watts.—*Ideal Industries, Inc., 4037 Park Ave., Sycamore, Ill.*



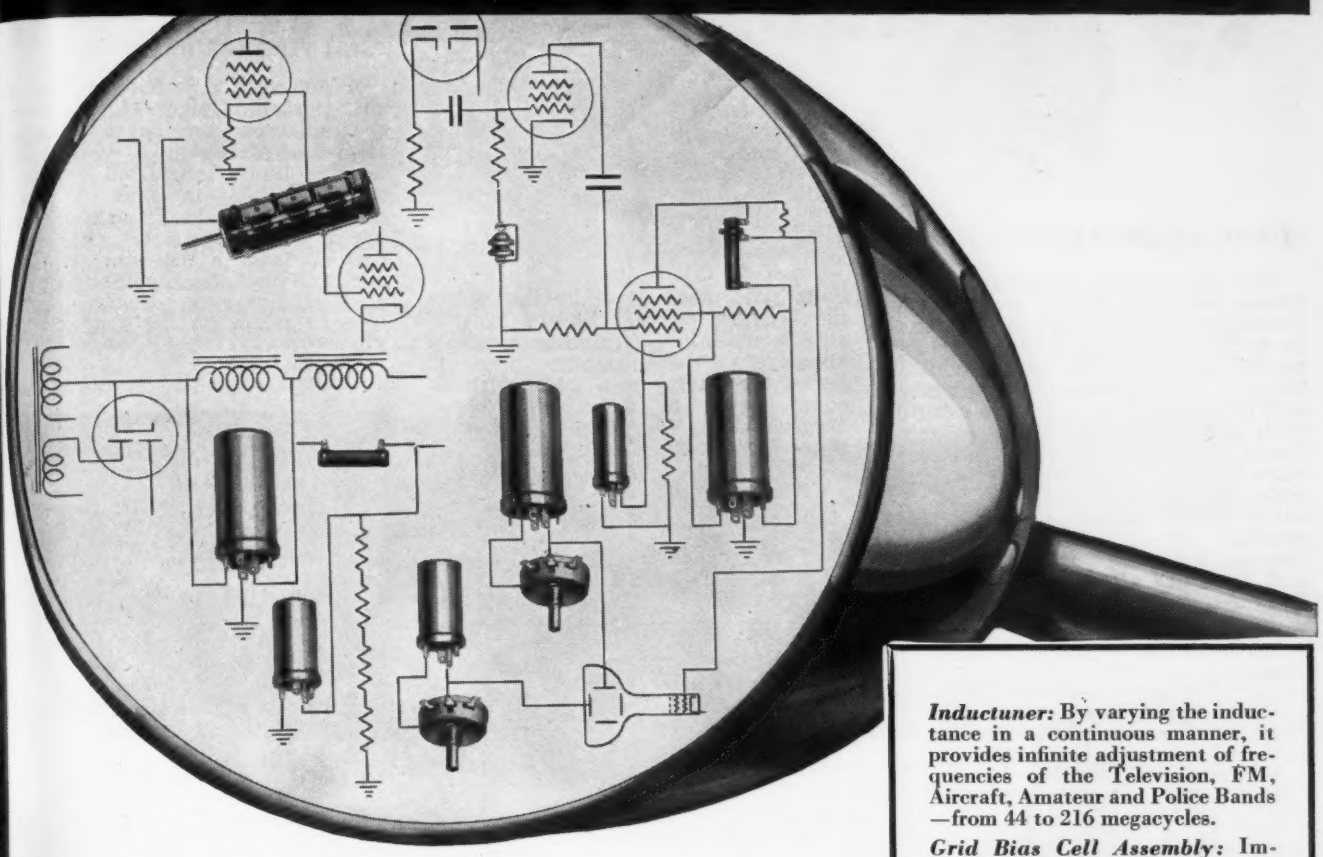
LINEAR POTENTIOMETER

Available in single units or ganged in multiple on one shaft to provide independent voltage outputs for several variables, this improved linear wire-wound potentiometer is guaranteed to have a service life in excess of 1 million cycles. Fabricated from precious metal alloys, the unit has an accuracy of 0.1% in the 3-in. size, and 0.15% in the 2-in. size. Overall resistance ranges from 100 to 100,000 ohms, the power dissipation being 4 to 5 watts.—*Fairchild Camera & Instrument Corp., Jamaica, N. Y.*

HIGH VOLTAGE CAPACITORS

To extend the usefulness of standard paper and oil-filled capacitors to the voltages encountered in television receivers and cathode-ray oscillographs their voltage rating has been increased. Series "84" are now made in ratings up to 10,000 volts dc working. Midget-can series "89" and round-can series "12" and "14" are available in double-ended design or with pillar terminals at either end and with adjustable ring mountings.—*Aerovox Corp., New Bedford, Mass.*

Mallory Contributions to Television



FOR quite a number of years now, Mallory has been looking ahead to television—has been planning, designing, building components that would one day find as widespread a use as its radio products already enjoy.

The result of this foresight is shown in the typical television circuits illustrated above—circuits in which ten different components find a place, three of which (Inductuner,* Videocoupler, Grid Bias Cells) are of exclusive Mallory design. In each of these components, quality ranks foremost—each is a truly "Approved Precision Product."

If you are developing or manufacturing television equipment—Mallory components will serve you well. Behind them are years of engineering know-how—and *that*, too, is at your beck and call. You are invited to write us for technical information or for any help that is within our province.

*Reg. U. S. Pat. Off.

Inductuner: By varying the inductance in a continuous manner, it provides infinite adjustment of frequencies of the Television, FM, Aircraft, Amateur and Police Bands —from 44 to 216 megacycles.

Grid Bias Cell Assembly: Improves picture quality by aiding low frequency response and effectively eliminating stray pick-up.

Videocoupler: Widens frequency response, resulting in better picture definition.

FP 550 Capacitor: A unique decoupling and screen bypass capacitor.

10 Watt Vitreous Enamel Resistor: Used as a voltage dropping or bleeder resistor in low voltage power supply.

WP 540 Capacitor: Bypass for vertical centering.

WP 510 Capacitor: Bypass for horizontal centering.

WP 505 Capacitor: Bypass in compact container for video stage cathode circuit.

FP 135 Capacitor: Filter in low voltage power supply; effectively eliminates 60-cycle "hum band" distortion.

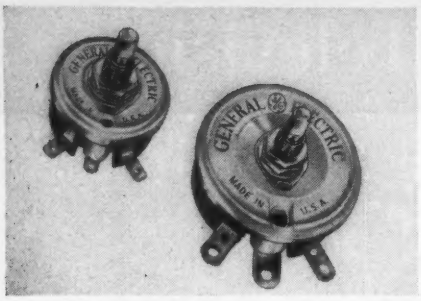
Carbon Controls: Used as tone, volume and contrast controls. (Not shown.)

Wire Wound Controls: Used for horizontal and vertical centering.

P. R. MALLORY & CO. Inc.

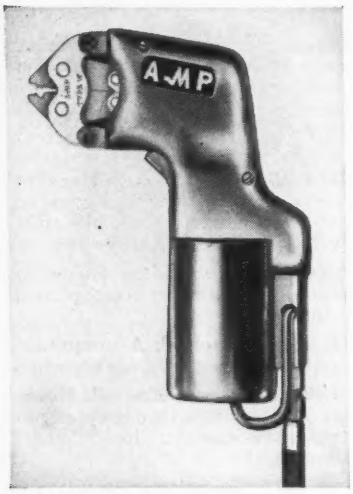
MALLORY APPROVED PRECISION PRODUCTS

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA



POWER RHEOSTATS

For applications involving dissipation of power these new power rheostats are available in 25- and 50-watt sizes and will furnish close action and long life under conditions of high ambient temperature and humidity. The units are wound with special alloy wire on a ceramic frame. The 25-watt size can be obtained in ranges from 35 to 5,000 ohms, the 50-watt unit from 35 to 10,000 ohms. Both units have tolerances of ±10% and rotate through 295°.—*Specialty Div., General Electric Co., Wolf Street Plant, Syracuse, N. Y.*

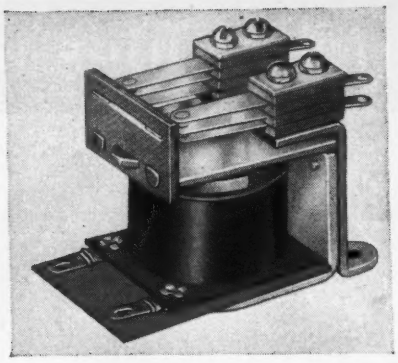


PNEUMATIC HAND TOOL

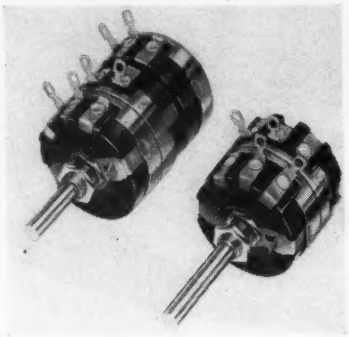
Installing solderless electrical terminals with speed, uniform pressure, and precision is the function of this pneumatic powered hand tool which is designed for production line assembly. Tool steel crimping jaws are readily interchangeable for various types of solderless terminals. Each set of jaws accommodates a number of wire sizes between 14 and 22. With 85 lb. air pressure 2000 lb. crimping pressure is provided.—*Aircraft-Marine Products Inc.*, 1616 *N. Fourth St., Harrisburg, Pa.*

MIDGET RELAY

Furnished in a large number of contact switch combinations up to and including four pole, double throw, the small, low cost series 600 relay consists of interchangeable coil and contact assemblies. Contact assembly can be used with any of the standard series 600 or 605



coils regardless of operating voltage. Short contact blades in the switch assembly eliminate contact "bounce". The maximum contact current capacity is 8 amp. with a consumption of 6 va.—*Guardian Electric Mfg. Co., Dept.* 600, 1622 *West Walnut St., Chicago* 12, *Ill.*



VARIABLE ATTENUATORS

Covering impedance ranges from 8 to 600 ohms these wire-wound L and T-pads are rated at a maximum dissipation of 2.5 watts and have a continuous range from 0.5 to 30 db attentuation in 90 degrees of rotation. The T-pads may be used as variable attenuators in stable line impedance circuits, while the L-pads find application as individual volume controls for multiple speakers.—*Electronics Dept., General Electric Co., Wolf St. Plant, Syracuse, N. Y.*

FLOCK SPRAY KITS

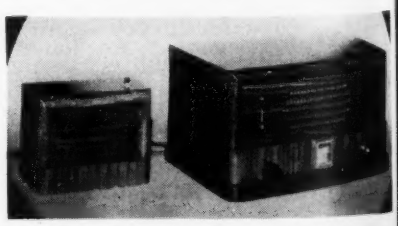
Applicable to phono turntables, cabinets, instrument cases, tool boxes, etc., this new blower spray gun distributes the flock evenly and blows each fibre into the undercoat vertically. A spray kit contains the blower gun, 2 cans of flock (brown and ivory), thinner, can of brown "Under Koat", brush and instructions. No special skill is required to apply the method.—*General Cement Mfg. Co.*, 919 *Taylor Ave., Rockford, Ill.*

HIGH VOLTAGE BATTERY

A 300-volt dry battery for use with portable Geiger-Mueller counters has been developed. The battery, one of the most powerful for its size, has a length of $2\frac{11}{16}$ in., a width of $2\frac{11}{32}$ in. and an overall height of $3\frac{15}{16}$ in. If used an average of four hours a day, the battery has at least a 350-hour life. For portable photoflash equipment a set of 6 batteries may be used.—*National Carbon Co.*, 30 *E.* 42 *St., New York* 17.

DICTATION INSTRUMENT

Weighing only 16 lb, the Gray Audograph is a new dictation instrument which utilizes thin, unbreakable, plastic discs for recordings, varying in length from 10 minutes each side on the 5¾ in. disc, to 31 minutes each side on an 8½ in. disc. A record positioning control permits instant location of any part of the recording. A typewriter control provides start-stop and backspace at fingertip touch. A light hand microphone or a desk type are available for recording.—*The Gray Mfg. Co.*, 230 *Park Ave., New York.*



RADIO-INTERCOM

The Radio-Utiliphone combines both the functions of a radio receiver and an intercom unit with as many as four slave units in the circuit. The receiver covers the standard broadcast band from 540 to 1620 kc. Intercom controls are located on the top half of the front panel and consist of "talk-listen" switch and slave station selector. The receiver is a 6-tube superheterodyne with permeability tuning and tuned rf stage. Operation is on ac or dc, 105-120 volts. Range for each station is 500 ft.—*Electronic Laboratories, Inc.*, 122 W. *New York St., Indianapolis* 4, *Ind.*

CALDWELL-CLEMENTS

buying market where you need it...

FACTORY ELECTRONICS

Reaching the largest number of buyers of electronic equipment throughout all industry, as well as designers and manufacturers of electronic apparatus!

ELECTRONIC INDUSTRIES & ELECTRONIC INSTRUMENTATION

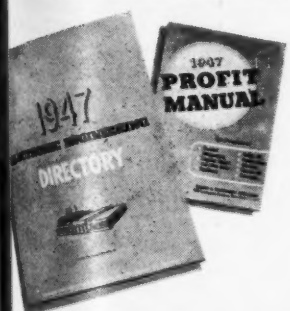
for manufacturers and industrial plants buying electronic products for induction heating, motor control, measuring, welding, sorting, industrial X-Rays, etc.

an easy-to-read format, convenient 11" x 16" tabloid size and generously loaded with photos and picture stories of actual factory electronic applications. Every ad rubs elbows with editorial material.

circulation:

25,000

FEATURING: *How to push quality up... and costs down! A monthly industrial electronic digest of* 150 *magazines! New products and where to buy them! "Who's" doing "what" in the field! A giant two-page, technical color chart in every issue!*



MERCHANDISING *and* SERVICING

Here's your show window for radio sets, parts, phonographs, records, refrigerators, ranges, washers, vacuum cleaners, toasters, all electrical appliances and related items being sold through radio-appliance stores:

RADIO *Television* RETAILING

- ***first*** in net paid and total circulation: 29,000.
- ***first*** in ABC circulation among independent radio-electrical retailers
- ***first*** in advertising volume and number of advertisers
- ***first*** in manufacturer-(and agency)-sponsored surveys
- ***first*** in editorial service to "Big Four" dealers *selling and servicing* radios, electrical appliances, records and accessories.

circulation:

29,000

FEATURING: *New products and where to buy them! How to make volume climb! Displays that help sell! How to meet the price-cutting trend! How to anticipate record sales! How to make credit selling work! How to make servicing pay off!* In short: *How to help the trade make more money!*

Caldwell-Clements serves every corner of the radio-electronic field with engineering handbooks, manuals, marketing data and directories! We will be glad to send manufacturers and agencies additional marketing information or a sample of this literature on written request.

Caldwell-Clements, Inc., **480 Lexington Ave., New York 17, N. Y., Plaza 3-1340**

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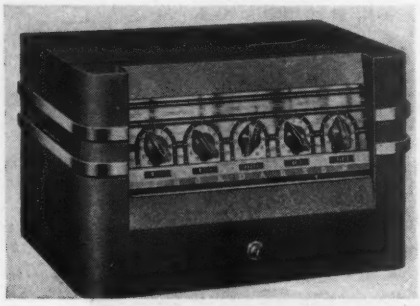
Communications Components

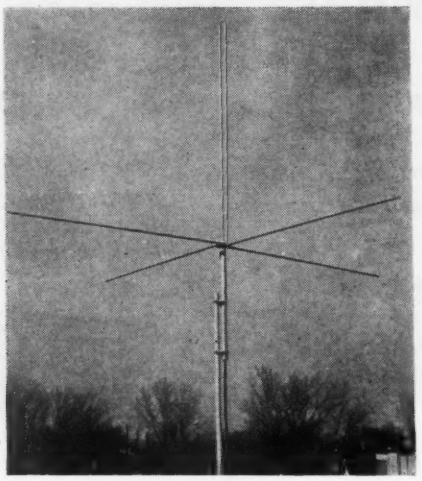


P.A. AMPLIFIERS

This 25-watt amplifier is one of a line of new public address amplifiers including an 8-watt and a 50-watt unit, a preamplifier and a booster. It provides two microphone and one phono-channel, which may be electronically mixed to feed the output circuits. Individual treble and bass controls are provided. With tone controls in normal position, frequency response is flat within 1 db from 30 to 15,000 cps. The hum level is 65 db below rated output.—*Thordarson Electric Mfg. Div., Maguire Industries, Inc., 500 W. Huron St., Chicago 10, Ill.*

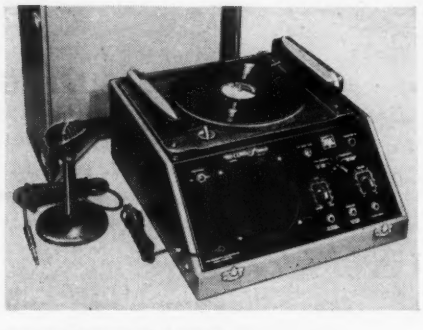
AUTOMATIC PILOT

Designed for automatic control of the attitude of aircraft in flight, Lear Electropilot Model L-201 weighs only 29 lb. and is adaptable to automatic approach, automatic altitude control, landing and take-off. The complete system consists of a controller, magnaslave compass, triple servo unit, amplifier, synchronometer, and gyros. The Electropilot operates from the standard 24-28 volt aircraft battery and consumes 10 amperes in operation. The system operates on the displacement principle without use of rate gyros and does not use mechanical or electrical follow-up systems.—*Lear, Inc., Grand Rapids, Mich.*



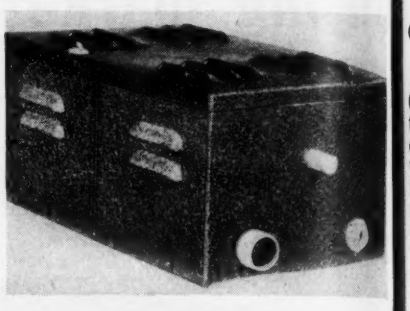
GROUND PLANE ANTENNA

Providing efficient impedance match for a 65 or 70 ohm coaxial transmission line the folded unipole is a vertically polarized ground plane antenna with the quarter-wave vertical element folded back on itself, and is intended for use in the 30-40 mc frequency range. Input impedance of the type 900 antenna is purely resistive varying between 57 and 90 ohms depending on frequency. With any 70-ohm cable standing wave ratio varies between 1.0 and 1.4 and never exceeds 1.5. The antenna is constructed of stainless steel and aluminum and weighs about 20 lbs.—*Andrew Co., 363 East 75 St., Chicago 19, Ill.*



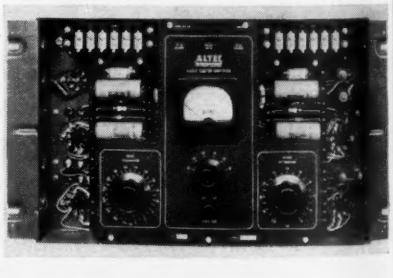
RECORDING UNIT

A combination recorder, record player and PA system, the portable model RC-47 Record-O-Fone provides for permanent recording from any source with immediate playback facility. Dual speeds permit recording of 12 minutes on a 10-in. blank at 33⅓ rpm or copying a 12-in. commercial record on a 10-in. disc at 78 rpm. Recordings of radio programs may be made with comments dubbed in. Monitoring is by means of a pair of headphones.—*Bell Sound Systems, Columbus, Ohio.*



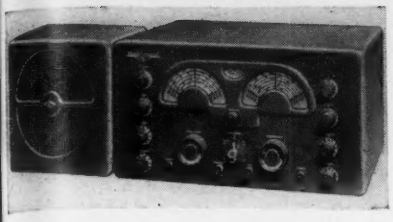
MARKER RECEIVER

Intended to provide reception of the 75 mc airway and instrument landing markers with aural and visual indication, the Lear marker receiver consists of a remote receiver and three-light indicator. The remote receiver is located in the radio compartment and is powered by the standard 24-volt battery with a consumption of 1.3 amperes. The indicator shows the plane's passage through the marker field. In addition, the appropriate note for each type marker is heard in the headphones. Power output of the receiver is 30 milliwatts. For the operation of the lights a signal input of 2,000 microvolts is required. The MBR-1 receiver weighs 7 lb., 11 oz.—*Lear, Inc., Grand Rapids, Mich.*



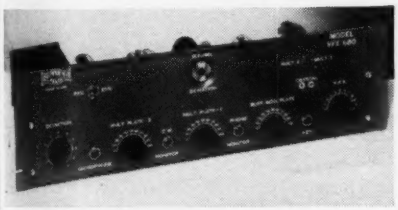
LIMITING AMPLIFIER

For use in film and disc recording, broadcasting and public address applications Altec Lansing A-322C limiter amplifier has rapid attack time, automatic volume control, 5 watts power output and thumpless limiting. The signal circuit of the amplifier consists of three balanced push-pull stages with a pair of cathode followers bridging the output tubes. An orthacoustic recording equalizer is provided. Gain without equalizer is 68 db at 1000 cps and the frequency response is flat within ±1 db from 20 to 20,000 cycles. Limiting ratio is 10:1, input and output impedances 600 ohms each.—*Altec Service Corp., 250 W. 57 St., New York 19.*



COMMUNICATIONS RECEIVER

Intended for amateur use on the 6, 10, 11, 20, 40 and 80 meter bands, the NC-173 communications receiver is a 13-tube superheterodyne with a frequency range extending from 540 kc to 31 mc and from 48 mc to 56 mc for AM phone and code reception. The receiver is provided with "S"-meter and AVC, operative on both phone and cw reception. An adjustable threshold noise limiter for phone and code use is provided. Circuit consists of one stage rf on all bands, separate hf oscillator, two IF stages, diode 2nd detector, noise limiter and two audio stages. Crystal filter is included. Power requirements are 110-120 or 220-240 volts, 50-60 cycle, ac.—*National Company, Inc., Malden, Mass.*



NFM EXCITER UNIT

Original developer of the Sonar narrow-band FM exciter unit for use on the amateur bands has brought out a new and larger model containing several additional features which will make it more useful. The new model (VFX680) is arranged to provide for the use of narrow-band FM on all amateur frequencies, when authorized. In addition it has a variable frequency oscillator as well as provision for "rubberizing" a control crystal so that frequency may be varied to cover any entire band with the VFO or a frequency variation from 30 kc on the 80-meter band to 480 kc on the 6-meter band is possible with crystal control. The circuit may be keyed for CW transmission, providing clean, chirpless signals, and provision also is made for frequency shift keying. Either may be used for break-in operation, shielding of the oscillator being sufficient to prevent receiver interference. There are two monitors, one for CW, with a built-in neon tube oscillator, and one for phone. The unit has eight tubes and is supplied for table or rack mounting, complete with power supply. One of the tubes is a 6AF6G for indicating rf carrier tuning and modulation deviation.—*Sonar Radio Corp., 59 Myrtle Ave., Brooklyn, N. Y.*

Model RX Smooth Power Motor

Smooth Power

THAT PLEASES YOUR CUSTOMERS

You'll make better friends of your customers when you equip your phonographs with General Industries *Smooth Power* Motors.

That's because of fine performance from the first instantaneous pick-up to the last note. Constant speed, quietness and vibration-free operation result in faithful, enjoyable reproduction.

These same high qualities characterize all *Smooth Power* mechanisms, including recording motors and assemblies and combination record-changer recorders. From our complete line, you can select fitting companions for your own fine products.

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NEWS OF FORTHCOMING MEETINGS

Marine Conference on Navigation Aids

With a purpose similar to that for which PICAO (Provisional International Civil Aviation Organization) staged its conferences and demonstrations here and abroad, an International Meeting on Marine Radio Aids to Navigation (IMMRAN) is to be held in New York and New London, Conn., starting April 28 and continuing two weeks. Some 60 nations will have representatives in attendance.

The meeting will consist of a series of lectures and technical discussions on the developments in the field of radio aids to marine navigation, and the demonstration of the latest types of equipment, including loran and radar. Actual tests will be carried out at sea on board vessels made available by the United States Maritime Commission, the United States Coast Guard and the United States Coast and Geodetic Survey.

The aim of the meeting is to inform the world delegates of the United States policy in this field and to demonstrate the progress which the United States has made in the development of marine radio aids to navigation. Accordingly, it is expected that the meeting will inform the delegates regarding the adoption of new radio aids to navigation by this government and the availability, type and quality of marine radio aid equipments produced by United States manufacturers. In addition, should it appear that fruitful conclusions and resolutions leading to world standardization of marine radio aids can be evolved during the progress of the meeting, such conclusions and resolutions will, of course, be recorded for future reference and utilization when the nations of the world meet to consider standardization of equipment in this field.

The United States will be represented at the meeting by representatives of industry, education and government. Dr. W. L. Everitt, University of Illinois, will serve as chairman of the meeting.

F. X. Rettenmeyer, Federal Radio and Telephone Corp., chief engineer, and Norman E. Wunderlich, executive sales director, Radio Division, fondle one of the new 25 kw tubes developed for the company's 50 kw FM transmitters

URSI and IRE Meet

A joint meeting of the International Scientific Radio Union (American Section) and the Institute of Radio Engineers will be held in Washington, D.C., at the Interior Dept. auditorium and George Washington Univ., May 5-7. Technical sessions will include papers on tropospheric and ionospheric propagation, radar, instruments and measurements, antennas, principles and circuit elements.

Television Conference

A one-day technical conference featuring television will be held in Cincinnati May 3, sponsored by the Cincinnati section of IRE. For information or reservations write E. J. H. Bussard, Crosley Corp., 1729 Arlington, Cincinnati.

Army Signallers Meet

Army Signal Association is to hold its first convention at Fort Monmouth, New Jersey on April 29. It is expected that nearly 1000 members will attend the gathering, which will adopt a constitution and elect permanent officers. Signal Corps Laboratories and Air Forces Laboratories will sponsor an exhibition of equipment.

New England Radio Engineering Meeting

The North Atlantic Region of the Institute of Radio Engineers, comprised of the Connecticut Valley Section and the Boston Section, will sponsor an all-day radio engineering meeting at the Hotel Continental in Cambridge, Mass., May 17. A luncheon, banquet and an exhibit will be featured. Papers to be presented at the technical sessions are:

"Low Drag Aircraft Antennas for Frequencies from 2 to 18 mc," John V. N. Granger, student, Harvard Univ., Cambridge, Mass.

"The Commercial Design of Geiger-Mueller Counter Tubes," Herbert Metten, Sylvania Electric Products, Inc., Boston.

"Recent Developments in Frequency Stabilization of Microwave Oscillators," William G. Tuller, Mass. Institute of Technology, Cambridge.

"A VHF Bridge for Impedance Measurements at Frequencies Between 20 and 140 mc," R. A. Soderman, General Radio Co., Cambridge.

"Design Problems of FM Receivers," Aldo Miccioli, associate, Dale Pollack, New London, Conn.

"Wartime Developments in Waveguide Theory," Julian S. Schwinger, professor, Research Laboratory of Physics, Harvard Univ., Cambridge.

Chicago IRE Meet

The 1947 Chicago IRE Conference, scheduled for April 19th at Northwestern Technological Institute, will feature an opening address by the president of IRE, GE's Dr. W. R. G. Baker. The Northwestern student branch of AIEE and IRE, called Electro-Tech Society, will provide laboratory demonstrations and conduct tours through the Institute's electrical engineering labs.

Papers to be presented are:

W. H. Kliever, Minneapolis-Honeywell Regulator Co., "A Magnetic Compass with Cathode Ray Sensing Element."

Dr. H. S. Snyder, Physics Dept., Northwestern Technological Institute, "Photocells and Low Noise Amplifiers."

Curtis F. Prangley, Patent Attorney, "Patents and the Engineer."

Dr. R. Adler, Zenith Radio Corp., "A Compact Electro-Mechanical Filter for the 455-kc I. F. Channel."

Thomas E. Lynch, Brush Development Co., "A Viscous Termination Crystal Pickup."

Dean Shankland, Farnsworth Radio & Television Corp., "Factory Testing of Television Receivers."

(Speaker to be determined), Collins Radio Co., "Crystal Synthesizer."

R. Cohen, RCA Tube Division, "R.F. Performance of Some Receiving Tubes for Television."

P. R. O'Connor, Illinois Bell Telephone Co., "Mobile Radio Telephone."

Leonard Mayberry, Hallicrafters Co., "A Variable Frequency Oscillator with Narrow Band FM."

R. S. Bowditch, Galvin Mfg. Corp., "Personal Plane Radio."

C. A. Cady, General Radio Co., "FM Monitor."

M. Marks, Raytheon Mfg. Co., "Phase Shift Modulator."

J. F. Bell, Zenith Radio Corp., "A System of High Efficiency Modulation Applied to Television."

4-750A

ANOTHER EIMAC TETRODE

Designed for

Industrial
Heating

Communications
Airline
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Experimental r-f

EIMAC 4-750A POWER TETRODE Electrical Characteristics	
Filament: Thoriated tungsten	
Voltage	7.5 volt
Current	20 amp
Direct Interelectrode capacitances (av.)	
Grid-plate	.24 μμf
Input	26.85 μμf
Output	7.78 μμf
Maximum Ratings	
D-C Plate Voltage	6000 max. volts
D-C Plate Current	700 max. ma.
Plate Dissipation	750 max. watts

Here's a new **Eimac tetrode**—the power step-up you have been asking to have added to the Eimac line.

Capable of 2-kw power output at 4000 plate volts, with less than 15 watts of grid drive, the 4-750A opens a new field of possibilities to designers of electronic equipment. A pair of these tetrodes, driven by low cost, low-power tubes, will supply more than 4-kw output.

A potential workhorse for communications and industrial use, the 4-750A has the ability to deliver its maximum power over a wide range of frequencies. Inherent characteristics include the familiar attributes of Eimac tetrodes—stability, economy, and dependability.

Complete technical data and performance characteristics will soon be available. Write now for your copy.

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RCA'S MOBILE TELEVISION FIELD PICK-UP

Completely equipped with cameras and monitoring equipment, RCA's newly developed mobile pickup will facilitate news and sports coverage and relay to studios

RADIO-ELECTRONIC MAGAZINES ABROAD

Readers have written in for lists of the principal technical magazines devoted to radio, electronics, and tele-communications in the countries of Europe. Presented here are the names of a number of such journals, most of which are regularly reviewed by Tele-Tech's "Wide-Reading" editor, Dr. Josepha Zentner, who abstracts and tranlates the more important articles each month for the benefit of our readers.

Belgium:

Bulletin de la Société Belge des Electriciens (Reports of the Belgian Society of Electrical Engineers), published by A. R. Matthis, 8 Rue Sabatier, Marcinelle, Belgium.

La Radio Revue (The Radio Review), published at 28, Rue du Prince Leopold, Anvers, Belgium.

England:

B.B.C. Quarterly, published by the British Broadcasting Co., Broadcasting House, London W.1, England.

Beama Journal for the British Electrical Industry, published by the British Electrical & Allied Manufacturers' Assn., Inc., 36 Kingsway, London, W.C.2, England.

Electronic Engineering, Incorporating Electronics, Television and Short Wave World, published by Hulton Press, 43-44 Shoe Lane, London, E.C.4, England.

G.E.C. Journal, published by the General Electric Co., Ltd., Magnet House, Kingsway, London, England.

Journal of the Institution of Electrical Engineers, published at Savoy Place, Victoria Embankment, London, W.C.2, England.

Journal of Scientific Instruments, published by the Institute of Physics, 19 Albemarle St., London, W.1, England.

Nature, published by McMillan & Co., Ltd., St. Martin's St., London, W.C.2, England.

The Philosophical Magazine, a Journal of Theoretical, Experimental and Applied Physics, published by Taylor and Francis, Ltd., Red Lion Court, Fleet St., London, England.

Post Office Electrical Engineers' Journal, published by Birch & Whittington, Epsom, Surrey, England.

Proceedings of the Physical Society, published by the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7, England.

Wireless Engineer, the Journal of Radio Research and Progress, published by Iliffe & Sons Ltd., Dorset House, Stamford St., London, S.E.1, England.

Wireless World, Radio and Electronics, published by Iliffe & Sons Ltd., Dorset House, Stamford St., London, S.E.1, England.

France:

Annales de Physique (Physical Review), published by Libraires de l'Académie de Médicines, 120, Boulevard Saint-Germain, Paris, 6e, France.

Bulletin de la Société Francaise des Electriciens (Bulletin of the French Society of Electrical Engineers), published at 10 Avenue Pierre-Larousse, Malakoff, Seine, France.

Hebdomodaires des Séances de l'Académie des Sciences, Comptes Rendus (Reports of the Weekly Meetings of the Academy of Science), published by Gauthier-Villars, Quai des Grand-Augustins, 55, Paris, France.

L'Onde Electric, Bulletin de la Société des Radioélectriciens (Electric Waves, Bulletin of the Radio Engineers' Society), published by Etienne Chiron, 40, Rue de Seine, Paris 6e, France.

Revue Générale de l'Electricité (General Review of Electricity), published at 12, Place de Laborde, Paris, 8e, France.

Revue Internationale de la Radio Electricité (International Radio Review), published by Etienne Chiron, 40, Rue de Seine, Paris, 6e, France.

La Télévision Francaise, la revue de la télévision, et Electronique, la revue des applications de l'électronique (French television, a television review, and Electronics, a review of electronic applications), published at 21, Rue des Jeuneurs, Paris, 2e, France.

Toute la Radio (Everything about Radio), published by the Société des Editions Radio, 9 Rue Jacob, 6e, France.

Le Vide (Vacuum Technique), published by the Société Francaise des Ingenieurs Techniciens du Vide, 44, Rue de Rennes, Paris, 6e, France.

Germany:

Annalen der Physik (Physical Review), published by Verlag von Johann Ambrosius Barth, Leipzig, Germany.

Elektrische Nachrichtentechnik (Electrical Communications Engineering), published by Springer Verlag, Berlin W9, Germany.

Elektrotechnische Zeitschrift (Electrical Engineering Publication), published by Verband Deutscher Elektrotechniker, VDE Haus, Berlin-Charlottenburg 4, Germany.

Funktechnische Monatshefte fuer Rundfunk, Hochfrequenztechnik und Grenzgebiete (Technical Monthly Radio Publication for Wireless, High Frequency Engineering and Borderline Subjects), published by Weidemannsche Buchhandlung, Berlin, Germany.

Hochfrequenztechnik und Electroakustik, Jahrbuch der drahtlosen Telegraphie und Telephonie (High Frequency Engineering and Electro Acoustics, Yearbook of Wireless Telegraphy and Telephony), published by Akademische Verlagsgesellschaft Becker und Erler Kom.-Ges., Leipzig, Germany.

Die Naturwissenschaften (Nature), published by Fritz Sueffert, Springer Verlag, Berlin W9, Germany.

Holland:

Philips Research Report, published at Eindhoven, Holland.

Philips Technical Review, published at Eindhoven, Holland.

Physica, published at The Hague, Holland.

Russia:

Journal of Physics, published by the Academy of Sciences of the U.S.S.R., Moscow, Russia.

Switzerland:

Brown Boveri Review, published by Brown, Boveri & Company, Ltd., Baden, Switzerland.

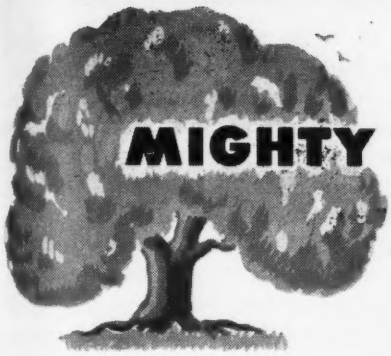
Bulletin des Schweizer Elektrotechnischen Verein (Bulletin of the Swiss Association of Electrical Engineers), published by the Schweizer Elektrotechnischer Verein, Stauffacherquai 36, Zurich, Switzerland.

Helvetica Physica Acta, published by E. Birkhaeuser & Cie., A.G., Basel, Switzerland.

Schweitzer Archiv fuer angewandte Wissenschaft und Technik (Swiss Reports on Applied Science and Engineering), published by Buchdruckerei Vogt-Schild A.G., Solothurn, Switzerland.

Measuring Magnetic Field in Betatrons

The change in ac permeability of a small Permalloy core transformer with superposed steady state magnetic field is used by E. C. Gregg, of the Case School of Applied Science, for measuring the magnetic field strength of a scale model betatron. One probe consisted of a 150-turn primary driven with ac and dc, while the 100 turn secondary was connected to an amplifier and null indicator, a balancing method being used. The cylindrical probe measured 0.08 in. in diameter and was 0.1 in. long; its accuracy was about 0.2%.



MIGHTY OAKS don't just happen

THEY GROW

from good little acorns

Du Mont's new "Acorn Television Package" perfectly illustrates the adage "Mighty Oaks from Little Acorns Grow." Du Mont's Unit Construction offers the key to progressive, economic television growth. It offers savings of up to 64% over earlier estimates for building commercial television broadcast stations. And permits expansion in keeping with programming needs—without obsolescence or replacement loss.

Yes, Du Mont, with 15 years of "television know how"—which includes building more television stations than any other company—now makes it possible for you to start your television station *without huge investment.* May we tell you more? Wire or telephone today . . . ask about the Du Mont "Acorn Television Package."

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Radio Receivers in Cuba

L. B. Nunez of Circuito CMQ, Monte Y Prada, Havana, advises us that Cuba now has 4,800,000 inhabitants and 425,000 radios, a ratio of 88.5 radios per thousand inhabitants. In Havana, where 70% of the potential market of Cuba is concentrated, there are approximately 250 sets per thousand persons, adds Nunez, whose company operates seven Cuban stations.

Licenses Under Cisin AC-DC Patent

Allied Engineering Institute, New York, has let it be known that the Radio Corporation of America has been licensed, under Cisin patent No. 2,086,256, to manufacture radio receiving sets using the transformerless ac-dc principle. Under the terms of the license, RCA licensees will also be granted the same privilege. This license follows an out-of-court settlement of an infringement suit instituted a number of years ago by the Cisin interests in the U.S. District Court for the Southern District of New York. The last action in the U.S. Circuit Court of Appeals was decided in favor of the Cisin patent and this resulted in the present settlement and license.

MARINE RADAR

Navigator on the "America", largest liner built in US, and one of twenty ships of US lines to be equipped with Raytheon radar, scans the scope on maiden voyage

High Permeability Alloy

O. L. Boothby and R. M. Bozorth of Bell Telephone Laboratories developed an alloy containing iron, nickel, and molybdenum for high permeability transformer cores. Specimens 0.014 in. thick have a maximum permeability of 800,000, an initial permeability of 100,000, a coercive force of 0.003 oersted, a hysteresis loss of 4 ergs/cm^3/cycle at $B_m = 5000$, a saturation induction of 8000, and a resistivity of 65 microhm-cm. In the form of 0.001 in. and 0.004 in. insulated tape, this material, called supermalloy, is formed into transformer cores which have an initial permeability of about 75,000.

Invisible Stars Made Visible

At the annual meeting of the American Association for the Advancement of Science held in December 1946 in Boston, Doctor A. E. Whitford of the Washington Observatory at the University of Wisconsin, explained how unnoticeable radiation originating at distant regions of the universe are being observed with the aid of lead sulphide photoconductive cells.

War Surplus Tubes

General Electronics, Inc., Paterson, N. J., has entered into a contract with the War Assets Administration for the distribution of a considerable assortment of electronic material including some two hundred varieties of transmitting and receiving tubes. To facilitate distribution a distributing center has been established at 1819 Broadway, New York.

Band-Pass Effect in Waveguides

A paper presented by L. Brillouin of Harvard University at a meeting of the American Physical Society (Columbia University, New York, January 30-31, February 1) discusses the band-pass effect of equidistant diaphragms placed in waveguides. A very strong variation of the phase velocity with frequency is observed. In linear electron accelerators or decelerators (for instance, the beam traveling-wave tube, described on page 57 of the December, 1946, issue of *Electronic Industries*) a definite relation between electron velocity and phase velocity of the waves is essential and the present expedient is suggested for these problems.

PICKING FM OFF ELECTRIC-LIGHT WIRES

Editors *Tele-Tech:* Commander McDonald has asked me to answer your inquiry about picking FM signals off the electric-light wires. All of our FM receivers are designed to do this both on the high band and on the low band.

This sysem of picking up FM is the development of an idea of Commander McDonald and was developed by us prior to the war. The very nature of FM makes such a pickup system satisfactory and we have been able to develop a good patent picture on it. It is not, of course, as effective as a well-installed outside dipole; nevertheless, it is a successful performer in a great many cases and to this day we do not know of any acceptable substitute for it on table-model receivers. We do the trick through the use of a choke in series with the power line and built right into the receiver chassis.

This system of extracting FM from the power lines is sometimes a little erratic in that you sometimes can do better from one outlet in a room than from another. Sometimes just reversing the plug in the outlet makes quite a change. This is, no doubt, due to the standing-wave pattern set up at any particular location. We have found some cases where one outlet positively will not work at all and the next will give excellent reception.

I happen to live more than 20 miles from the Chicago loop and at my residence I got perfect reception from the Chicago stations on the 100-mc band even when some of them were running with 250 watts.—J. E. Brown, Assistant Vice President and Chief Engineer, Zenith Radio Corp., 6001 Dickens Ave., Chicago 39, Ill.

has your shop got the "TOOL ROOM TROTS?"

How much time is wasted "on the road" while punch press operators and set-up men go back and forth to the tool room to get punches and dies for a short run set-up?

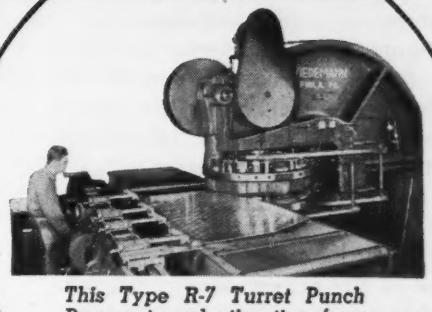
SEE A WIEDEMANN

With a Wiedemann Turret Punch Press, the operator remains at the machine . . . no need to make numerous time consuming "trips," since 11 to 32 punches and dies are carried in the turret . . . ready for instant piercing . . . always at the operator's fingertips. In addition, a Wiedemann saves you hours of layout time. On some machines, layout time is completely eliminated because of material handling gauge tables that position the material ready for piercing by obtaining the X and Y coordinate from blueprints or charts.

WIEDEMANN MACHINE COMPANY

1817 SEDGLEY AVENUE • PHILADELPHIA 32, PENNA.

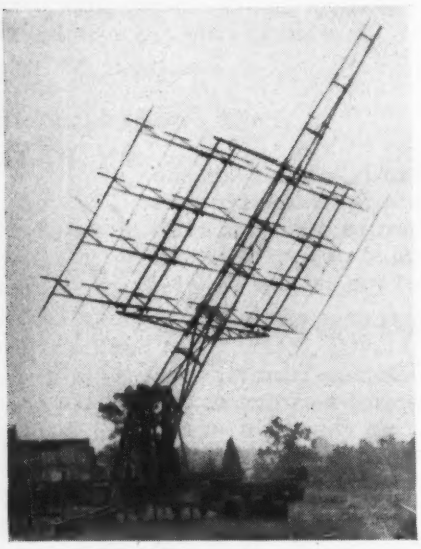
Send today for the complete story of short run piercing economy . . . Bulletin 92 . . . and then if you'd like to see a Wiedemann in operation, we'll tell you the shop nearest you that does short run piercing with a Wiedemann.



This Type R-7 Turret Punch Press cut production time from over 12 hours to 73 minutes on short run jobs. Get the proof!

METEORS DETECTED BY RADAR

Scientists of the National Bureau of Standards are using radar to investigate the ionization caused by meteors. Beginning the night of October 7 and continuing through October 12, reflections from the meteor shower associated with the



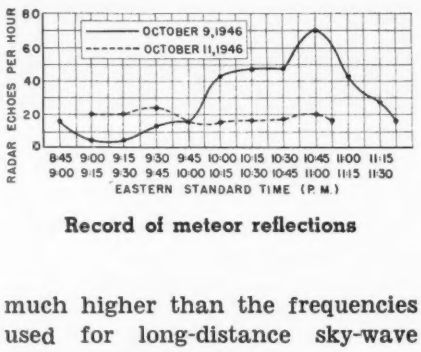
Antenna used by Bustan's CRPL in tracking meteors and charting ionosphere disturbances

Giacobini-Zinner Comet were clearly visible on the oscilloscope screens of the radar set. The investigations, which are to be continued by the Central Radio Propagation Laboratory of the Bureau of Standards, are expected to indicate the effect of meteors on radio waves, particularly important in FM broadcasting and long range radio communication and navigation.

Signals were observed on both the A and PPI oscilloscopes of the radar set. A photographic record was kept of the PPI indications while the A scope was monitored by an operator who kept a log of the time, range, and approximate duration of the reflections. The peak of the meteor shower was expected on the evening of October 9. The rate of occurrence rose from approximately 8 per hour between 7:30 and 8:30 to a peak of over one per minute between 10:30 and 11:00, coinciding approximately with the predicted time of 10:00 for the maximum intensity of the Draconid shower. Following this maximum, the rate fell to about 20 per hour after 11:15. Distances ranged from about 60 to 200 miles. Duration of the transient radar reflections was usually one second or less, although a considerable number lasted for several seconds.

The radar used in these investigations is the standard Signal Corps type SCR-270-D, operating at about 107 megacycles and transmitting 25 microsecond pulses at a repetition rate of 400 per second, with a peak power of approximately 100 kilowatts.

Ionospheric investigations have shown that ionized gases will reflect radio waves below a given frequency, allowing higher frequency waves to pass through. The frequency that will just be reflected by a region of ionized gases is proportional to the square of the density of ions. Due to the amount of frictional energy dissipated by a meteor, the hot gases in its trail should be ionized for a brief instant to a much greater extent than is the ionosphere. It is known that the 100 megacycle radar waves are able to penetrate the ionosphere. However, the ionization in the trails of meteors should be sufficiently intense to reflect radio waves at least in the region of 100 megacycles—a frequency relatively low in terms of modern radar but



Record of meteor reflections

much higher than the frequencies used for long-distance sky-wave radio communication.

One way in which meteors may affect radio waves is to cause the "bursts" on FM channels. Some scientists, such as Prof. J. A. Pierce of Cruft Laboratory, Harvard University, believe that a large part of the ionization of the E layer of the ionosphere may be caused by meteors. A knowledge of the behavior of the E-layer is of primary importance since it controls radio propagation on many of the frequencies used for radio communication and radio navigation.

In charge of the project is Victor C. Pineo, radio engineer, under the supervision of Ross Bateman, chief of the Experimental Ionospheric Research Section. Heading the entire program of ionospheric research, propagation studies, and microwave research are Drs. J. H. Dellinger, chief, and Newbern Smith, assistant chief, of Division XIV—Central Radio Propagation Laboratory — of the Bureau of Standards.

VHF RECEIVER

(*Continued from page* 51)

The rf Q was about 60. Image about 400, spurious about 5,000 times down. Oscillator warm up, 70 seconds to within 1 kc of final frequency. The voltage stability was excellent as the heater drift was used to buck the plate voltage drift, so if plate and heater varied together, total variation of about 6 kc at 125 mc for 95 to 135 line voltage resulted. The oscillator was of the ultraudion type with critical L/C ratio.

Temperature Stability

Temperature - stability - overall performance was better than one part per million per F° with temperature compensating capacitor of 80 ppm. Dial resetability = 4 kc mostly caused by backlash in the lead screw.

This performance on temperature largely resulted from good fortune in choosing the correct constants. Nearly a quarter million measuring checks went into this oscillator design. Most of the runs were made by putting the oscillator in an oven and operating at 250° F. Runs were made on the head sometimes as high as 375° F. since all we had to avoid was the softening of the soft solder.

The best piece of luck came in choice of the dial materials for temperature expansion characteristics. The dial mechanism expands the usual 16 parts per million per degree thermal expansion, and as a consequence the core was pushed back from the front panel by that amount. The coil assembly however also was pushed back from

the same front panel by an equal amount, so while both units moved, they hung together. We were very lucky to find the necessary tough steels for the pushrod, the stable grain-growth metal for the cam, and so on, which added up so exactly to the expansion coefficient of the head material. The head is adapted to die casting, and the entire construction principals were for a turret type of multi-band set. The tuning range is at present limited by the SLF portion of the tuning curve with available cores, but it is felt this can be extended considerably.

Much of the coil design details were described in the former article. The work on the core took about a year to combine reasonable permeability, reasonable Q and a temperature coefficient below one ppm.

It will be noted band switching for a turret type construction is not inside the tank circuit, but merely switches tube capacities. There is a complete absence of resonant loops up to 600 mc and the maximum voltages are always available at the tube terminals.

For somewhat lower accuracy of dial, the cam can be made without the adjustable feature. A ground steel ring like a piston ring can be forced into a suitable recess on the back of the cam to provide a line of contact with the nose of the lead screw.

Although this first model of the design is complex and somewhat costly, it does provide a unit with complete overall performance equal to a crystal. Ways have been found subsequently where the construction can be simplified since the possibility of attaining the principle characteristics sought for have been shown.

BuStan Adds Four

National Bureau of Standards which has long broadcast standard frequency and time signals at 2.5, 5, 10 and 15 mc has added four new services to widen reception coverage to practically the whole world. The new frequencies are 20, 25, 30 and 35 mc, will carry time announcements, time signals, the standard audio frequency of 440 cycles per second, and radio propagation disturbance and warning notices.

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"ELECTRON GUN" NAVIGATION COMPASS

A significant advance in compass design, the electron gun compass, which is capable of precise readings unattainable by conventional magnetic compasses, was demonstrated at the recent annual meeting of the AIEE in New York. Containing no moving parts, the device can be coupled to the directional gyroscope of an electronic autopilot to fly an airplane on any preselected course or may be used to control ships automatically.

The "Cathotrol" compass, developed by the Minneapolis Honeywell Regulator Co., is 7 in. long, 1 in. in diameter, and is suspended vertically on gimbals. The instrument, which is no longer than a flashlight, may be mounted at the tip of an airplane wing or at the masthead of a ship where it is removed from magnetic disturbances.

A specially-designed cathode ray tube, containing four tiny target plates in place of a fluorescent screen, is the heart of the compass. The electron gun fires a constant focused stream of electronics at the four target plates, the beam

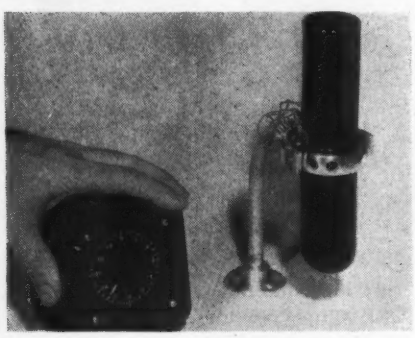


Fig. 1—View of indicator and compass suspended vertically on gimbal joints

being equally divided between the plates when the gun is pointed in the direction of the earth's magnetic field. In any other position the magnetic field of the earth bends some of the beams so that they strike the target unevenly.

Signals picked up from the target plates are fed to a "vector computer" and electronic amplifier, which measures the infinitesimal vector differences of the beam impact, and in turn feeds signals to a small, highspeed gyro. The gyro is used to eliminate errors resulting from tilt, and transmits its signals to the autopilot and indicators. The compass, though adjusted to read "north," actually points west, since the earth's magnetism deflects the electron beams in a westward direction. Because the CR-tube measures intensity as well as direction of magnetic pull, it is possible to use the instrument as a magnetometer in prospecting for oil and ores.

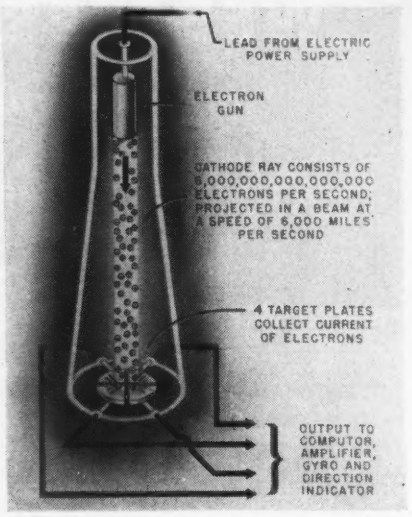

LEAD FROM ELECTRIC POWER SUPPLY
ELECTRON GUN
CATHODE RAY CONSISTS OF 6,000,000,000,000,000 ELECTRONS PER SECOND; PROJECTED IN A BEAM AT A SPEED OF 6,000 MILES PER SECOND
4 TARGET PLATES COLLECT CURRENT OF ELECTRONS
OUTPUT TO COMPUTOR, AMPLIFIER, GYRO AND DIRECTION INDICATOR

Fig. 2—Diagram of electron gun showing the four equally divided targets

TELEPHONOGRAF

(*Continued from page 69*)

ized persons is effectively prevented. In the event that the code numbers are forgotten, the subscriber may use his key to unlock the Ipsophone on returning to the office.

When recording and reproducing messages in response to a call from any standard telephone located anywhere in the telephone system, the Ipsophone functions as follows: Upon connection with the Ipsophone, the caller hears the announcement, "Hello, hello . . . . This is the office of John Doe. Your message will be automatically recorded . . . . Ready! . . . . Please speak now . . . ." Any message received within twelve seconds after the word "now" and lasting not longer than three minutes, will then be recorded. A "busy" tone indicates when the thirty-minute capacity of the wire has been exhausted.

If the party calling is familiar with the private code and wishes to actuate the playback mechanism, he will wait for the word "Ready!" and will then immediately say, "Hello, hello." Instead of recording, the Ipsophone then reads off the consecutive numbers from one to ten, with a four-second pause between each number. After each of the three selected code numbers the caller repeats "Hello, hello," thus providing an "acoustic key" which unlocks the recorded messages. If the wrong response is made to the number sequence the only result is a "busy" signal. After hearing all messages, the caller may, if desired, erase the magnetic record by merely repeating "Cancel, cancel," thus preparing the wire for the receipt of additional messages.

In addition to the ten code buttons, the control panel of the Ipsophone provides ten buttons for selecting various other functions of the instrument (as shown in the accompanying drawing), such as interoffice or interplant communication by private wire, dictation, conference recording, etc. When performing its major function of remote telephone recording, suitable buttons are depressed and locked by the right hand key, to prepare the instrument for remote operation by outside callers. The accompanying illustration shows only the control unit of the Ipsophone. The complex dual recording mechanism, with its system of relays, amplifiers, etc., is contained in a separate cabinet measuring about 3 x 3 x 1½ ft.

Television Expansion

In the four-week period between January 27 and February 23 Allen B. DuMont Laboratories, Inc., shipped in excess of $875,000 worth of television receivers. Remaining backlog of unfilled orders totals more than $3,100,000. Shipments to date have been almost entirely to the New York metropolitan area. Distribution schedules of the DuMont organization call for early deliveries of television receivers to Philadelphia, Washington, D. C., Schenectady, Detroit, Chicago, St. Louis and Los Angeles.

EFFECT OF TREES

(*Continued from page 68*)

To check this, the frequency was varied over a range of 140 mc about the normal frequency of 3260 mc. The data, after correction for the frequency characteristic of the equipment, including the aerials, is shown plotted as curve 1 in Fig. 1. The explanation of the unexpected results is that in winter, when the trees are nearly transparent, two nearly equal rays reach the receiver, one by the direct path, the other reflected, probably from a roof about 1300-1500 ft. distant. In summer the direct ray is practically blocked by the trees and the *indirect ray is the one received,* undisturbed by out-of-phase signals!

This special and unusual case is described because such interference phenomena must often occur in UHF reception. Once understood, the condition often can be avoided by proper choice of antenna location. This is clearly indicated by Fig. 2, which shows that by moving the antenna about 40 yards the received signal was increased by about 24 db. It should be noted that this motion was at right angles to the line of sight. The wide changes in signal with a change of only 1 foot in antenna location reemphasizes the importance of experimentation, coupled with a knowledge of propagation, when installing VHF, FM or TV antennas.

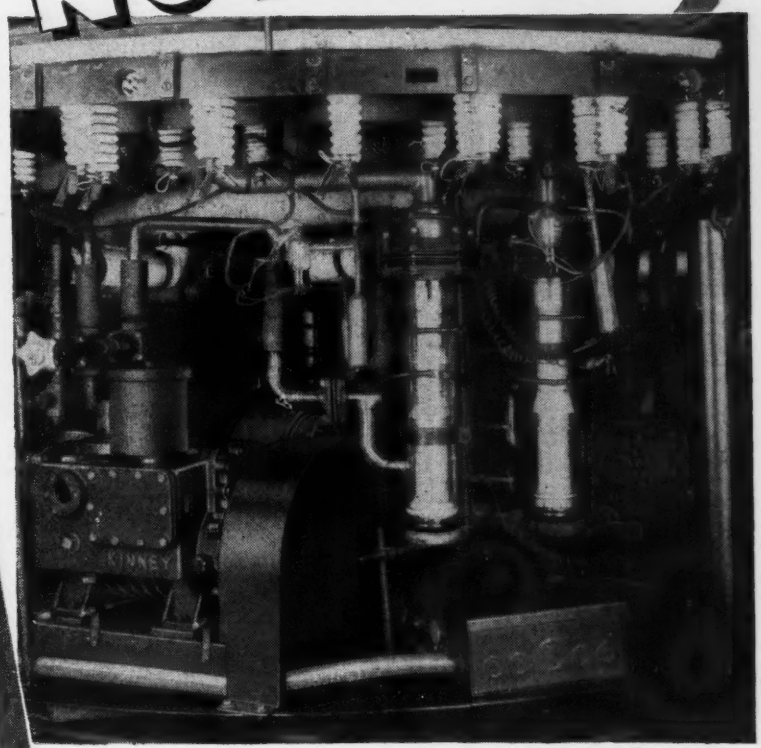
Dr. Megaw concludes his report,* of which the above is but a portion, with the statement that the effects of obstacles such as trees and hills in centimeter wave transmission can be shown, in general, to be in satisfactory agreement with Fresnel diffraction calculations for simple objects.

*"Some Effects of Obstacles on the Propagation of Very Short Radio Waves."

Boyton Leaves Adalet

J. C. Boyton, founder and president of Adalet Mfg. Co., Cleveland, Ohio, has sold his interests and severed connections with the company. His son, J. R. Boyton, secretary, has also severed his connections. Henry D. Stecher is president of the newly formed organization. After a rest Boyton will return to Cleveland and seek a new connection.

PRODUCING A LOT OF NOTHING



Compact installation of Kinney Compound High Vacuum Pumps used to back diffusion pumps in the manufacture of ultra high frequency tubes at Raytheon Mfg. Co., Waltham, Mass.

IN A SMALL SPACE

The compact design of Kinney High Vacuum Pumps enables them to be grouped closely with auxiliary equipment . . . shortens pipe lines . . . saves valuable floor space. Kinney Pumps are self-contained units, easily installed. Having automatic lubrication and oil sealing, they produce high vacuums indefinitely with minimum attention.

The faster pump down and lower ultimate pressures of Kinney High Vacuum Pumps shorten production time and cut costs in vacuum processing—exhausting lamps and tubes, sintering alloy metals, coating lenses, producing drugs, etc. Kinney Single Stage Vacuum Pumps produce low absolute pressures to 10 microns; Compound Pumps to 0.5 micron.

Write for Bulletin V-45.

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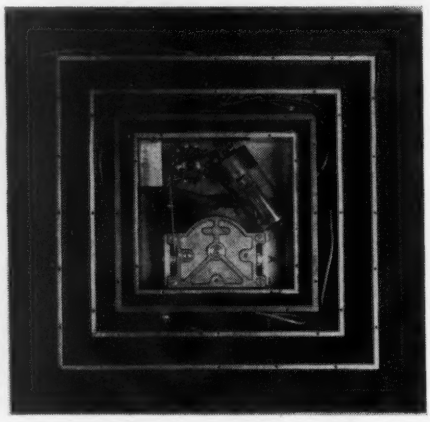
We also manufacture liquid Pumps, Chucks and Rheostats. Distributors.

BUSTAN'S QUARTZ CRYSTAL CONTROL CLOCK

The only continuous time signal service provided by any country broadcasting signals accurate to a microsecond every second on 5, 10 and 15 megacycles over station WWV for use in navigation, seismology, geological surveys, scientific laboratories and industry has been made possible by a quartz crystal electronic clock, developed by the National Bureau of Standards.

The heart of the Bureau's crystal clock consists of a quartz crystal with a series resonance frequency of approx. 100,000 or 200,000 cycles per second. The frequency of the crystal generated in an electronic oscillator circuit is divided with no loss of accuracy to 60 cycles per second. This 60 cycle frequency supplies power to a synchronous motor which, through gear trains, drives contacts that give intervals of one minute, five minutes, and 30 minutes to control the automatic announcement equipment of the transmitters.

The motor also operates a one-second contact which opens an electrical gate for broadcasting highly accurate second pulses, each 0.005 seconds long and consisting of five cycles of a 1000-cycle frequency. The accuracy of the second pulses is determined by the crystal oscillator frequency which controls a square wave generator to supply pulses during alternate 1/200th second intervals.



View of part of oscillator and crystal in temperature controlled oven

Accuracy of crystal frequency is within a few parts in one hundred million. Due to possible phase shifts and other difficulties the pulses are accurate to one part in one million. The absolute time is supplied to the Bureau by the Naval Observatory.

COMPARING FM WITH AM FOR AIRCRAFT

(*Continued from page* 56)

The interference to be expected with FM in the frequency range 70-100 mc was investigated in connection with the AN/TRC-1 equipment.[17] Theoretical calculations were based upon the requirement that to avoid interference, the interfering signal should be 6 db below the desired signal at the limiter grid, to insure capture of the receiver by the desired signal. Hence the required frequency separation depended upon the strength of the desired signal, the distance between the receiver and the source of interference, the rf power output of the source of interference, and the spurious responses of the receiver. Tests confirmed the theoretical conclusions.

When the source of interference was a nearby 50-watt transmitter, it was found that in general a frequency separation of at least 10 mc was required. The interference problem is closely allied to that of jamming, and it would appear that FM receivers should be more proof against jamming up to the point where the capture effect permits an interfering signal to take over. For stronger interference there may be cases where the desired signal could be distinguished in the background of the output of an AM receiver, whereas it would not be distinguishable in the FM receiver.

Some workers in the FM field have stated that without the limiter, the behavior of FM in the presence of interference is the same as that of AM, i.e., the capture effect would be missing. Other workers have hesitated to say what would happen in the absence of a limiter. The point has not as yet been investigated.

With respect to size and weight of equipment, there seems to be a definite advantage for FM. The FM transmitters in equipments built to date for lower frequencies have been much lighter than comparable AM transmitters.[18,19] In a comparative study of equipment operating at 39 mc,[19] it was found that on the average a 25-watt FM transmitter required an input of 180 watts from the power mains, and that a 15-watt AM transmitter required 200 watts. The power requirements of the receivers were almost identical (70 watts for the FM receivers and 68 watts for the AM receivers). Data on weights are not available. The absence of heavy af power equipment is a decided advantage in favor of the FM transmitter. For low-power equipment, however, this advantage is not pronounced.

General Conclusions

It appears from this investigation that FM has inherent capabilities for greater range and greater suppression of noise than has AM. To secure the greater range, narrow-band operation is preferable to wide-band operation. If the allowances for frequency drift in transmitters and receivers are very great, the rf response curves of the receivers become so wide that narrow-band operation cannot be obtained. In any event, temperature control of crystals is now possible with simple equipment and it would appear to be desirable to permit a greater number of channels to occupy a given spectrum.

FM seems somewhat more critical as to tuning than is AM. However, the improvement in performance against noise is considerable, and precise tuning is not required.

The "capture effect" of FM prevents simultaneous reception of two signals when one is stronger than the other by more than 6 db, but insures interference-free reception of the desired signal. In general it renders the FM receiver somewhat less susceptible to jamming.

As to size and weight, the advantage seems to be on the side of

[17] Report of Army Air Forces Board, Orlando, Fla., Radio Interference Tests with the AN/TRC Radio Set. LOGA Report No. S-150.

[18] I. R. Weir, loc. cit.

[19] "Study of Frequency Modulation vs. Amplitude Modulation," notebook from the files of Lt. Col. W. S. Marks, Ft. Monmouth, N. J.

FM especially as the power of the transmitter increases. The receivers are approximately the same; the FM receiver is somewhat larger, when there is a difference, due to the higher employable IF amplification.

Noise limiters are necessary in AM receivers to enable communication to be carried on in the presence of pulse interference. It is felt as a result of this investigation that FM receivers are capable of a higher degree of noise suppression, since in addition to the balanced discriminator (which balances out much of the noise) limiters may be used in both the af and rf circuits. To date it has not been necessary to employ audio-frequency limiters in FM receivers.

The design of FM receivers seems at present to be done entirely on an experimental basis, and it seems that considerable experience is necessary on the part of the manufacturer to secure the advantages of which FM is capable. It may well be that such experience is lacking at present in the vhf band.

The Engineering Division of the Army Air Forces, Wright Field, Dayton, Ohio, has now under way (Contract No. W 33-038-ac-8791) with Bendix Radio a program of flight tests in which four narrow-band and one wide-band FM equipments will be tested against three AM equipments. These tests are to be supplemented by laboratory measurements. The question of AM versus FM is still highly controversial, the supporters of FM being in general more ardent than the supporters of AM. It is hoped that the Wright Field tests will furnish sufficient information to enable a factual choice to be made.

Video Wire Charges

The Bell Telephone Co. of Pennsylvania has been given special permission by the FCC to establish charges for television transmission by wire or radio or combination of both. Under the company's tariffs charges for local channels are at the rate of $20 per month per ¼ circuit mile; installation charge of $50. For terminal amplifiers the installation charge is $250 and maintenance at $60 per month. For receiving amplifiers the installation charge is also $250 with maintenance at the rate of $90 per month.

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Series MH or the famous "Humdinger" extra-compact rheostat or potentiometer. Wire winding held in grooved fibre base. Body only 9/32" deep.

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SO Radar Indicator unit with CR tube, focusing and deflection coils, azimuth scale, all controls, tubes and components. Used and in good condition.....$100

SO Radar accessory range unit, with AC Voltmeter on front of cabinet Complete $35

5 ft section of 10 cm waveguide with flanges on each end $15

In fact we also have complete SO Radars
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3J31's just received. One cm magnetron listed at $95.00.
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2J38 (3245-3263 Mcs) Complete with magnet. 37.50
2J42 (3 cm) Complete with magnet..... 37.50
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Magnet for any magnetron 12.00
KLYSTRON oscillator tubes 2K25/723 ab designed for 3 cm operation. New. With complete data. Listed at $38.00, reduced to.. 7.75
McNALLY KLYSTRON 707B. Limited quantity 15.00
Tunable external cavity for 707B 3.50
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30 mc oscillator-amplifier with 2 6AC7's. Uses 723ab, Waveguide input, xtal detector.
With 6AC7's 10.00
With 6AC7's, 723ab and 1N34 ..... 16.50
Thermistor Beads (D-170396) ..... .95

Microwave signal generator, 2700 to 3000 mc. Regulated power supply 115v/60c. contains output meter. Value $400. OUR PRICE..... $75

Pulse transformer, high voltage D169271—Special $9.95

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Silver Plated Directional Couplers with a 20 DB drop with:
15° bend in wave guide 15" long $4.40
30° bend in wave guide 10" long 3.95
90° bend in wave guide 15" long also
90°bend in coupler 5.00

SECTIONS

2½ ft. silver plated with 180° bend (2" radius) 4.50
10 cm wave guide 16 ft. long, per ft..... 2.00
2½ ft. 3 cm wave guide choke to cover fitting.. 4.50
5 ft. 3 cm wave guide section, per ft..... 1.95
Slotted dipole antenna 3 cm 4.00
Brass choke flanges, opening ½Z x 1", 7/16" thick .60

NEW C.R. TUBES

Tube Type	Approx. List	Your Cost	Tube Type	Approx. List	Your Cost
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5BP1	20.00	4.95	705A	22.50	6.75
5BP4	27.00	7.95	241B-WE	85.00	40.00
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5FP7	32.00	3.50	3B24	12.00	3.95
			3C45		5.95

Sockets for 5CP1; 3BP1, & 5BP1 and similar types of tubes .....$.95

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G.E., C-D, W.E., and other well known brands.

1 mf 300 vdc	$ .25	6 mf 600 vdc pyr	$.95
2 mf 300 vdc	.30	10-10-10 mfd synchro	
4 mf 300 vdc	.35	capacitor 90v, 60c	2.50
4 mf 400 vdc	.55	1 mf 1000 vdc	.90
5-5 mf 400 vdc	1.15	2 mf 1000 vdc	1.10
2 mf 550 vdc	.30	1 mf 1500 vdc	1.20
.25 mf 600 vdc	.25	.4 mf 1500 vdc	.20
.85 mf 600 vdc	.30	1 mf 2000 vdc	1.10
1 mf 600 vdc	.35	2 mf 660 ac/-000	.95
2 mf 600 vdc	.40	.1-.1 mfd 7000 vdc	1.75

HI-VOLT CONDENSERS

2 mf 4000 vdc 23F47 .....$5.75
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.75 mi. 20,000vdc 14F136 .....22.00

HI-VOLT TRANSFORMERS

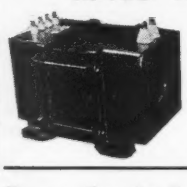


PLATE TRANSFORMER, 115v — 60-cycle primary. 6200 volt-ct-700 mil secondary. Size 11"x14"x10". $39.95

Same transformer without center tap $34.95

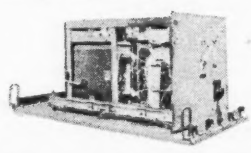
Power Supply for LM-18 freq. meter

Output: 290v @ 20 ma; 13v @ 600 ma.
Input: 105-125v @ 60 cps; 260 ma; 27.6 W. with type 84 rectifier tube; shock mounted. Complete with input and output plugs $14.75

HI-VOLTAGE POWER SUPPLY

POWER UNIT RA58-A

$116



Ideal for breakdown insulation testing, or as a source of power for a pulse transmitter. This unit supplies continuously variable voltages between 500 and 15,000 volts, DC at 35 ma. A voltage Doubler circuit using two 705a rectifiers and two 1 mf condensers is employed. BMS ripple voltage at maximum power is 6%. THIS UNIT OPERATES FROM 115v/60c. Variable voltage is obtained by means of a Variac in the primary circuit of the high-voltage transformer. Size is 21"x17½"x29" deep. Net weight 314 lbs.

APS-10 modulator assembly includes 2J42 Magnetron, magnet, output wave guide, 2—3B24's—3C45 relays, blower motor, relays, other parts. Together with low voltage power supply assembly, chokes, condenser, transformer, both a buy for $50.00

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AN RC CIRCUIT

(*Continued from page* 41)

from cathode to ground instead of the external oscillator, the circuit should provide the capacity and negative resistance necessary for sustained oscillations.

The circuit of Fig. 7 was constructed to verify this. For the network $\omega RC = \frac{1}{2}$ at a frequency of 4000 cps. Using G_1 obtained from the curve in Fig. 5, and taking g_m to be 6000 micromhos, we find C, from Equation (5) to be about .03 mfd. To obtain a frequency of 4000 cps, an inductance of 50 millihenries would be required. Actually, a 40-millihenry choke was used, and the frequency of the oscillations turned out to be about 4500 cps, agreeing well with the calculated value for $C = .03$ mfd and $L = 40$ mh.

The frequency was controllable by varying B+ (which changes screen and plate voltages and therefore g_m). When B+ was changed from 200 to 300 volts, the frequency changed from about 5000 cps to about 4000 cps.

Variable Inductance

If the network of Fig. 3 instead of the one in Fig. 2 is used in the circuit of Fig. 6, the cathode of the tube looks like an inductance $L_e = 1/G_1 g_m \omega$. Now, the real and imaginary parts of Equation (2), the gain of the network of Fig. 3, are represented by the curves of Fig. 5 if $1/\omega R_1 C_1$ is taken as the abscissa. It can be seen that in the region about $1/\omega R_1 C_1 = 1$, G_1 is approximately proportional to $1/\omega$, so that $G_1\omega$ is approximately constant; therefore in this region $L_e \sim 1/g_m$.

Webb to Produce Magnetic Cores

John C. Webb, previously sales manager for Micro-Ferrocart Products Div., Maguire Industries, Stamford, Conn., and former vice-president of the Ferrocart Corp. of America, has organized the Stanwyck-Webb Magnetic Core Corp., with plant and laboratories in Ossining, N. Y. R. H. LaSalle, former Ferrocart production manager, has been appointed plant manager of the new firm.

MAGNETIC SOUND

(Continued from page 67)

netic track can be modulated with sound from the original at the same time.

The magnetic recording assembly holds three heads. Each has a light spring bias so that it rides against the film. The upper head is energized at 40 kc and acts as an eraser. This coil is energized with a half to one ampere of current to provide sufficient demagnetization. The recording is accomplished by the center head whose main winding receives the audio frequency from the amplifier and transforms it into magnetic variations on the magnetic track.

Below the recording head and surrounded by a mu-metal shield for isolation is the direct pickup. This pickup head feeds through an amplifier and reproduces sound which was recorded on the film 50 milliseconds before.

Results of tests on the experimental system indicate that the frequency characteristic is flat within ±3 db from 50 to 12,000 cycles. Wave analyzer measurements indicate an inter-modulation distortion of 4% at normal recording levels when a 100 cycle signal was combined with a 7,000 cycle signal, the latter 12 db below the former.

New Big Screen TV Receiver Coming

Newly established in Nutley, N. J., is Industrial Television, Inc., which will design, manufacture and install television equipment and other electronic devices. The organizing personnel includes Horace Atwood, Jr., president and chief engineer, Robert L. Ringer, Jr., secretary-treasurer, Louis Rehak, factory manager, and Charles M. Puckette, Jr., production engineer. All were formerly associated with Allen B. DuMont Laboratories, Inc., Passaic, N. J.

First product of the new concern will be a direct viewing television receiver, with large screen, especially designed for public viewing as in taverns, clubs, schools, etc. Offices and factory of the company are located at 36 Franklin Ave., Nutley, N. J.

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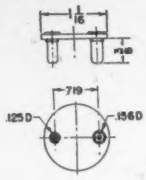

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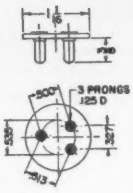

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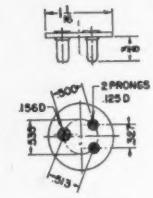

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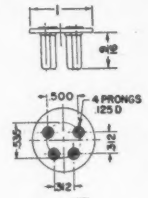

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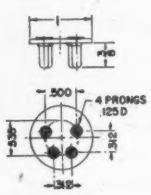

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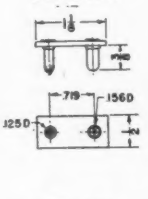

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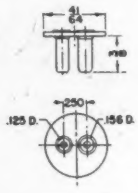

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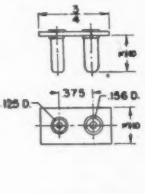

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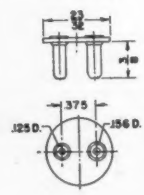

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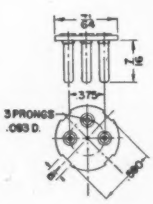

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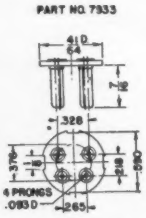

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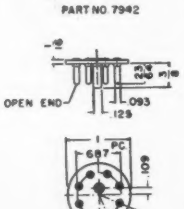

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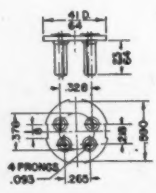

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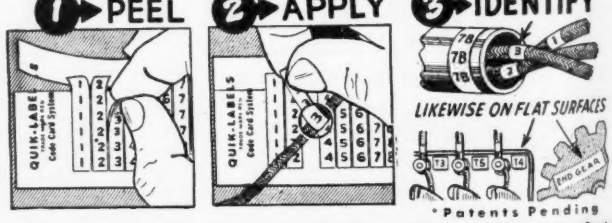

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NEWS OF INDUSTRY

(*Continued from page* 84)

8—An additional high frequency broadcasting band has been added at the request of the State Department between 25,600 and 26,100 kc.

9—The band 27,185-27,455 kc has been widened to 27,160-27,480 kc, to be primarily for the use of the industrial scientific and medical service, with sharing permitted by amateur, fixed and mobile services.

10—The power limitation in the band 29.7-30 mc has been eliminated.

11—The Commission's recent announcement regarding the frequency 2450 mc for the use of the industrial, scientific and medical service has been appropriately incorporated.

12—Some slight adjustments were made in the high frequency maritime mobile service-allocations as follows:

(a) The 4 mc band now starts at 4133 kc rather than 4135 kc, and the starting points at 6, 8, 12 and 16 mc have been adjusted accordingly. The 2 mc ship telegraph band was shifted to 2065-2105 kc.

(b) The ship telegraph bands have been widened by 20 kc at 4 mc and pro rata according to the harmonic relationship previously established for the ship telegraph bands at 6, 8, 12 and 16 mc.

(c) The 4 mc coastal telegraph band has been reduced by 40 kc.

(d) The 4 mc ship telephone band and its associated coastal telephone band have each been reduced by 5 kc.

(e) 8350 kc was selected for the ultimate air-sea rescue frequency.

Berman Honored

The Longstreth Medal, annual award of The Franklin Institute for inventions of high order, is to be presented to Samuel Berman, research engineer of the Waugh Laboratories Div. of Waugh Equipment Co., New York, during Medal Day ceremonies on April 16. He will receive the medal "in consideration of the development of a metal locator for use in surgery which has greatly facilitated the location and removal of foreign metallic bodies imbedded in the tissues". This device, the Berman metal locator, was used extensively by military hospitals during the war.

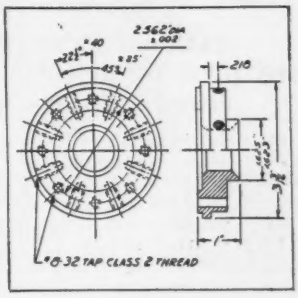
Tape Recorders By Audio Devices

Audio Devices, Inc., 44 Madison Avenue, New York, pioneer in the development of transcription equipment, has let it be known that during the past year the company has done considerable research on iron oxide coated vinyl tape. Though disks are high on the wave of popularity, and likely will stay there, tape recording, which now combines long playing time with wide volume range, has certain advantages, points out President William G. Speed, that make it particularly adaptable for specific services.

Precision Adapter for Drill Presses Perfects Alignment—Prevents Drift!

The new Aetna Adapter, of aluminum alloy, fits the columns of most small drill presses—assures accurate milling and accurate deep hole drilling—without a drill jig. It firmly and accurately holds interchangeable drill bushings close to work.

Precision alignment is accomplished through an eccentric aligning bushing, which once set needs no further adjustment. Filler bushings cover the entire bushing range up to ½". Stops to locate the piece to be drilled, are attached to the press table or directly to the adapter. Milling chatter is avoided. Chip interference is eliminated. Overlapping holes can be drilled without punch marks, or indication of run-out, with drills as small as 1/32" diameter. ¼" holes can be drilled more than 6" deep with as little as .006" drift.



Example of piece drilled with Aetna Adapter

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WIDE READING

(*Continued from page 75*)

height of the line joining the transmitting and receiving antennas above ground at the midpoint of this line; one third of this height is the equivalent receiving antenna height. This method has been developed in connection with the Alexandra Palace television station and applies to wavelengths of the order of 7 meters.

Test Equipment for Theater Servicing

E. Stanko and P. V. Smith (Journal of the Society of Motion Picture Engineers, December, 1946, pp. 457-463)

The various testing instruments included in the servicing equipment for checking theatrical sound installations are described as to their performance. Circuit diagrams including dimensions are shown of the special VoltOhmyst (dc voltages from 0.10 to 1000 volts, resistance from 0.1 ohm to 1000 megohms, ac voltages from 1 to 1000 volts, dc current from 0.1 milliampere to 5 amperes) and of the Triatic tester (capacitance from 10 micromicrofarads to 80 microfarads).

Magnetoresistance of Iron-Nickel Alloys

R. M. Bozorth (Physical Review, December, 1946, pp. 923-932)

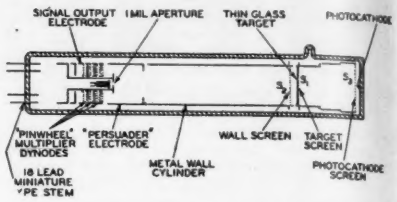
Changes of electrical resistivity of iron-nickel alloys with magnetization and with mechanical tension were measured. The results are interpreted on the basis of the domain theory. Positive and negative magnetostrictive alloys are considered and the influence of longitudinal as well as transversal magnetic fields is studied.

Radio-controlled Torpedo

V. K. Zworykin, R. D. Kell, G. C. Sziklai, P. K. Weimer, H. B. Law, and S. V. Forgue (RCA Review, Vol. VII, No. 3, pp. 293 to 366)

Several articles by these authors cover the general development and particular features of radio-controlled torpedoes. A glider torpedo when released from the carrier plane transmits picture signals of the target area to the plane which controls the automatic pilot of the torpedo by radio signals adjusted according to the instantaneous position of the target on the television picture.

Reduction in weight and space being of primary consideration, a miniature modification of the



Cross sectional diagram of the Mimo tube

image orthicon, the Mimo tube (diameter 1½ in., length 9 in.) was designed. It incorporates fine mesh screens S_3 and S_2 to control the electric fields in front of photocathode and target, respectively. Its structure and performance as well as details of the associated television transmitter circuit are set forth.

Coil Pulsers for Radar

E. Peterson (The Bell System Technical Journal, October, 1946, pp. 603 to 615)

Pulsers to provide the short square-wave voltage pulses required for magnetrons are described. The wave-shape distorting properties of coils with non-linear cores are used. Two special circuits providing low-power and high-power pulses, respectively, are shown, their operation explained, and the pulse shapes obtained considered.

Engineering Controls

Engineering Controls, Inc., is the new corporate name of the firm of manufacturing, designing and consulting engineers who, for many years, have operated internationally under the name Pacific Enterprise Products Co. Lloyd C. Harbert, formerly vice-president and general manager, is now president of the new corporation. William G. Corey, Los Angeles, consulting engineer, is vice vice-president in charge of engineering and Forrest W. Monroe of Forrest Monroe & Associates, Income Tax Consultants, is secretary and treasurer. Included in the reorganization are plans for expanded plant facilities and enlarged engineering personnel. Main offices continue at the present location, 2833 East 11th Street, Los Angeles 23, Cal.

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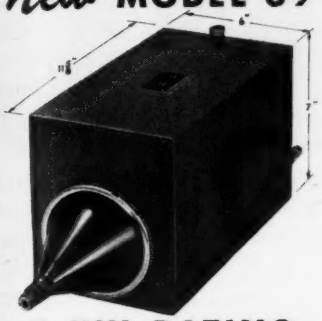

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Both Offer
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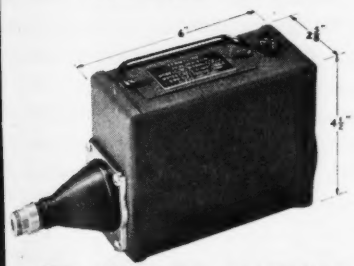

75 WATTS RATING
(with auxiliary cooling)
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Police Officers View 152-162 MC Demonstration

More than 100 police officers of state, county and city departments agreed that high quality transmission on the 152-162 mc. band compared favorably and in some respect was superior to the 30-40 mc. band after witnessing day-long propagation survey of Motorola police radiotelephone equipment at the Dearborn, Michigan Police Department. The tests were held by the Michigan Chapter of APCO and were under the guidance of Marion Henry, Superintendent of Communications for the City of Dearborn.

The Motorola portable station Model FMTRU-50-B operated from local utility power sources feeding the antenna from 200 ft. of 7/8 in. copper concentric transmission line. Three cars were equipped with Motorola 30-watt FM radiotelephone units and these cars reported solid coverage over 28 miles distance, covering points between the city and Monroe, Plymouth and Mt. Clemens. In downtown Detroit business districts, the cars cruised under viaducts and bridges but maintained constant contact with other cars up to eight miles distant.

The Motorola triple-skirt colinear coaxial antenna erected permanently on the top of Dearborn's 185-foot tower is just two feet from a 33.1 ground plane antenna which operates the city's 500-watt transmitter using amplitude modulation. Despite the proximity of the antennas, no interference disrupted either communication system.

Switchcraft in Calif.

David H. Ross has been appointed California representative of Switchcraft, Inc., 1735 Diversey Parkway, Chicago 14, Ill. Ross, operating The David H. Ross Co., will do business from 420 Market St., San Francisco, Calif.

JFD in Chicago

JFD Mfg. Co., 4117 Ft. Hamilton Parkway, Brooklyn, N. Y., has established Illinois headquarters in Chicago. The office will be in charge of factory representative Edward E. Wineblatt, Hotel Montery, 808 Junior Terrace, Chicago.

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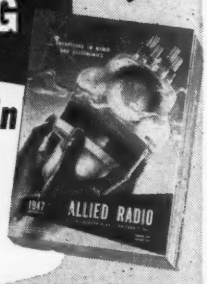

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ALLIED RADIO

PERSONNEL

Ralph H. Langley has been named vice-president and engineering head of Olympic Radio and Television, Inc., Long Island City, N. Y. He joined the company in October, 1946, has been active in radio engineering circles for nearly 30 years, starting with the Marconi Wireless and Telegraph Co., later joining General Electric and still later becoming director of engineering for Crosley. During the war he was connected with Hazeltine where he did much work on radar research.

Edward J. Kelly has been appointed works manager of Emerson Radio and Phonograph Corp., New York. He formerly was vice-president of the North American Phillips Co. and prior to that was affiliated with RCA for twenty-five years.

Dr. John A. Hipple, an authority on the design and use of the mass spectrometer, has been appointed chief of the Atomic Physics Section at the National Bureau of Standards. He will direct research on the ionization and separation of molecules by electron impact and the processes involved in these phenomena. Dr. Hipple joins the Bureau staff from the research laboratories of Westinghouse Electric Corp., where he has been section manager in the electro-physics division.

Dr. J. A. Hipple

Brig. Gen. Marshall

Brig. Gen. James C. Marshall has joined the engineering staff of the M. W. Kellogg Co., of Jersey City, N. J., and New York, N. Y. A veteran of the atom bomb project, Gen. Marshall will apply a lifetime of knowledge and experience to the new engineering and reseach projects in the Kellogg Co. program.

John L. Abbott has joined North American Philips Co., Inc., 100 E. 42nd St., New York, as application engineer in the industrial X-ray division. From 1941 to 1946 he was employed by Wright Aeronautical Corp. as senior metallurgist.

Dr. Daniel E. Noble, general manager of the communications and electronics division of Motorola, Chicago, has been appointed vice president in charge of that division. He joined Motorola in 1940 as director of research and for the past six years has been engaged in the development of FM communications equipment for mobile services and military applications. Dr. Noble is chairman of Panel 13 of RTPB (dealing with mobile radiotelephone service), chairman of RMA's Emergency Service Equipment Committee, and chairman of the IRE Committee on Railroad and Vehicular Services.

Dr. D. E. Noble

W. A. Weiss

Walter A. Weiss has been appointed supervisor of quality control for the radio tube division of Sylvania Electric Products, Inc. He will be responsible for policies and coordination of activities in all plants of the division, making his headquarters at Emporium, Pa. Joining Sylvania in 1941, the following year he was appointed supervisor of quality control for the Emporium plant.

Leo L. Helterline, Jr., has been appointed chief engineer for Sorensen & Co., Inc., Stamford, Conn. In his new capacity, he will be responsible for the design and development of all Sorensen products, which include voltage regulators, transformers, Nobatrons and special electronic equipment. He has been with Sorensen since January, 1946, as senior project engineer. Prior to joining Sorensen, he was affiliated with Sylvania Products, Inc., as a quality control engineer.

Fred M. Andrews has been appointed chief engineer of WROL and WROL-FM, operated by the Stuart Broadcasting Co., Knoxville, Tenn. Andrews, who during the war was associated with Philco, will supervise installation of a 5-kw RCA transmitter for WROL and the 76-kw installation of WROL-FM.

F. M. Andrews

A. G. Gable

Albert C. Gable, for the past four years administrative assistant of engineering of the tube division of General Electric Co.'s electronics department, Schenectady, N. Y., has been appointed assistant engineer of that division. First employed by G.E. in 1929 in the test department, he later transferred to the vacuum tube engineering department.

Victor M. Harkavy has been appointed to the Insuline Corp. of America engineering staff and will be in charge of new product development and design. Recently he was assistant division chief of Crystal Research Laboratories and prior to that was project engineer and chief inspector for DeJur Amsco Corp.

Leo E. Duval, Jr., has joined the commercial engineering staff of the lighting products division of Sylvania Electric Products, Inc. A veteran of the Southern Philippines Campaign, he was a specialist in radar maintenance and repair work and graduated from the Army Electronics Training Course at Harvard and M.I.T.

Arthur J. Sanial has resigned as chief engineer of the Atlas Sound Corp., New York. He is now devoting his full time to consulting engineering in loudspeaker and sound system design, measurement, etc., with offices at 168-14 32nd Ave., Flushing, N. Y.

Samuel M. Thomas has been appointed assistant chief engineer of RCA Communications, Inc., New York. He joined the organization in March, 1946, and has been responsible for much of the engineering and planning phases of the company's modernization program. A reserve officer during the war, Thomas reached the rank of brigadier general, doing important communications work with the Persian Gulf Command and later with the Military Government in Berlin.

Adelbert E. Joost has been appointed to the research staff in the division of industrial physics of Battelle Institute, Columbus, Ohio. He formerly was associated with Sylvania Electric Products, Inc., New York.

L. F. Mathison, sales engineer, Bendix Radio Division, has been appointed manager, Bendix Radio's Newark Sales Office located at 33 Elizabeth Ave., Newark, N. J. This office will handle the sale of railroad communications equipment as well as yard loudspeaker systems and specially designed VHF two-way radio equipment for taxicabs and emergency services.

Sidney A. Lewis, former captain in the Army Chemical Warfare Service, has joined the U. S. Stoneware Co.'s Process Equipment Division's sales engineer force. An authority on electroplating on plastics, Lewis will make his headquarters at the New York office of U. S. Stoneware, 60 East 42nd St.

John J. Glauber has been appointed chief engineer in charge of engineering and development of radio transmitting tubes by United Electronics Co., Newark, N. J. He formerly was with Federal Telecommunications Laboratories, New York, in charge of design and development of UHF high power pulse tubes.

Joseph A. Waldschmitt has joined the firm of Page Consulting Radio Engineers, Washington, D. C., as consultant. He formerly was television and FM engineer at station WOR, New York.

(*Continued on page* 122)

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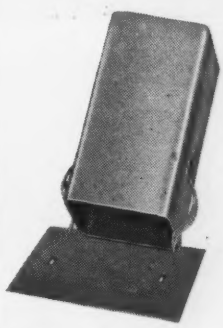
- *Lower Assembly Cost*
- *Strong Positive Grip*
- *No tolerance problems*



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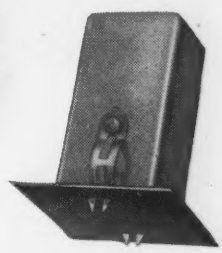

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New relays are being developed for special purposes. Send your requirements to SIGMA for dependable relay recommendations.

(Continued from page 121)

Merril A. Trainer has been made manager of RCA television equipment sales. He is a pioneer TV research and development engineer, has been in charge of the company's television terminal equipment development. His headquarters will be in Camden.

Richard Waring has been appointed director of engineering of the Olympic (formerly Hamilton) Radio and Television Corp., New York.

Eric J. Young has joined Production Methods, Inc., 48 E. 43rd St., New York, as senior design engineer. For over twenty years he has been active in electronic and mechanical engineering in England, Iraq, Palestine and Venezuela. During the war he was a project engineer for Western Electric Co., and since then has been engaged on design and research engineering for the S.S. White Dental Mfg. Co.

Radio Station Brokers

Ray V. Hamilton, who has been executive vice president of Universal Broadcasting Co., San Francisco, has resigned that position, and with J. W. Blackburn, Washington, D. C., has formed a new firm of radio station brokers. Blackburn-Hamilton Co. will act as brokers for persons interested in buying or selling radio stations. The San Francisco office of the company will be located at 235 Montgomery Street; the Washington office at 1011 New Hampshire Avenue.

Wheelco in England

Wheelco Instruments Co., Chicago, has completed arrangements for the production of its instruments in England. They will be manufactured by Ether, Ltd., Birmingham.

RCA in Kansas City

A new district sales office in Kansas City, Mo., has been added to the field organization of the RCA Engineering Products Dept. It is under the direction of C. M. Lewis and is located at 221 W. 18th St.

FCC Denies Columbia Color TV Petition

The Federal Communications Commission has denied the petition of Columbia Broadcasting System which sought the immediate establishment of engineering standards for color television. In making known its decision, which follows many months of public hearings and demonstrations of both the Columbia sequential system and RCA's simultaneous electronic method, held in New York, Princeton and Washington, the Commission pointed out that many of the fundamentals of color television have not yet been adequately field tested. The hope was expressed that experimentation would be continued.

Danziger Establishes Engineering Service

Albert Danziger, formerly connected with Danziger Radio Laboratories in New York, and latterly senior engineer for Freed Radio Corp., has organized Radio Engineering Co., to specialize in engineering service for manufacturers of receivers. Danziger is president and chief engineer of the company which has established its laboratories at 8 State Street, New York. The company plans to concentrate on high quality receivers for both AM and FM, later will enter the field of television receiver design. No manufacturing will be done, work of the organization being confined to consulting and engineering design.

McNaney with Vultee

Author Joseph T. McNaney, whose article, "Remote Tuning Unit for Aircraft Radio," appears in the March issue of *Tele-Tech,* is connected with Consolidated Vultee Aircraft Corp., San Diego, Calif., where he is a design engineer in the radio and electric laboratories of that organization. He was connected with Bendix Radio Division, Baltimore, at the time the article was prepared.

Raytheon Chicago Office

Headquarters of the sales department of Raytheon Mfg. Co.'s radio receiving tube division has been established at 445 Lake Shore Drive, Chicago. Ernest Kohler, Jr., is sales manager.

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RECORD enthusiasts are critical customers—whether they be devotees of Bach or boogie-woogie. Better and better reproduction of their favorite recordings is an insistent demand that must be met.

The General Electric Variable Reluctance Pickup can help you to meet that demand. It will appeal immediately to the technical mind due to its simplicity and direct resolution of difficulties often associated with phonograph pickups.

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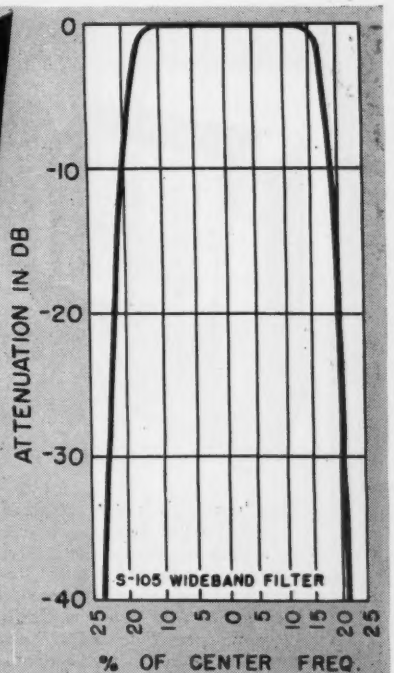

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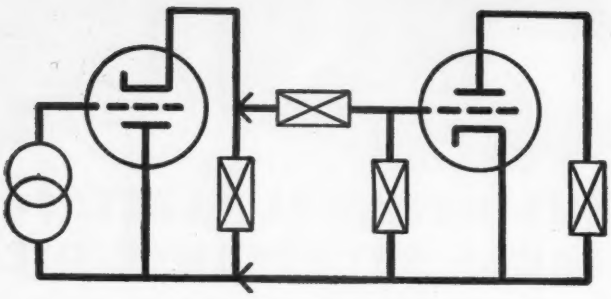

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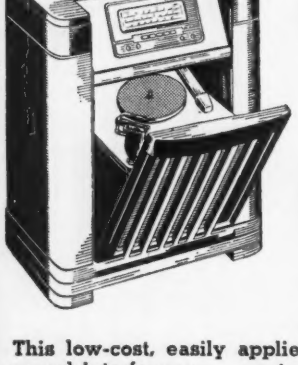

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New Bulletins

DC METERS

Characteristics, construction, specifications and detailed descriptions of type 501 high-sensitivity portable dc meters are contained in an 8-pg folder issued by Rawson Electrical Instrument Co., Cambridge 42, Mass. The booklet covers single and multirange microammeters, milliammeters, and ammeters, as well as millivoltmeters and voltmeters. The instruments are of the permanent magnet, D'Arsonval type movement.

CRYSTAL CONTROL

Suitable for all frequency control applications Valpey crystals are available in eight types described fully in a handy folder issued by Valpey Crystal Corp., Holliston, Mass. Most units are supplied either in flat rectangular types for vertical mounting or suitable for horizontal mounting in standard tube sockets. Photographs, physical characteristics, frequency tolerance, frequency range, and price are given for each type. Crystals for use on amateur bands are also listed.

PRECISION PIVOTS

Having been successfully used in long-life phonograph needles, Permometal, made of osmium alloys, has also been applied to a wide variety of precision pivots, which are wear resistant, non-abrasive, non-corrosive, and non-magnetic. Different alloys are used according to each particular application. The characteristics, history and applications of Permopivots are described in a 12-pg. booklet issued by Permo, Inc., 6415 Ravenswood Ave., Chicago 26, Ill.

KLYSTRONS AND MICROWAVE EQUIPMENT

A bulletin summarizing the specifications, catalog numbers, and illustrations of various families of klystrons for use as reflex oscillators and amplifiers is being distributed by Sperry Gyroscope Co., Inc., Great Neck, N. Y. Also described are Microline instruments for microwave tests and measurements, associated components, couplers, transformers, etc., as well as aircraft instruments, including automatic direction finders, a detonation indicator, the Strobodyne and the Gyrosin compasses.

MEASURING INSTRUMENTS

Providing a quick source of condensed information, a 4-pg. folder has been issued by Roller-Smith, Bethlehem, Pa., on a line of instruments, circuit breakers, switchgear, etc. Switchbar, panel, and portable instruments are described and some of the pertinent technical data are presented in tabular form.

CERAMIC INSULATORS

The principles of ceramic insulating materials are discussed in form No. 720 catalog issued by Centralab, Div. Globe-Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wis. Twenty-eight pages include information on standards, design criteria, body characteristics and listings of established shapes and sizes. Steatite, Cordierite, Zirconite, and a wide range of dielectric materials are explained along with prolific illustrations. Especially valuable are a listing of ceramic tolerances and design data, and a table of average characteristics.

TERMINALS AND CONNECTORS

A variety of terminals for wide applications in communications and industrial electronics are described in a portfolio-catalog issued by Aircraft-Marine Products, Inc., 1523 N. Fourth St., Harrisburg, Pa. The portfolio is thumb-indexed according to the various types of connectors and terminals, such as Diamond Grip, Corrosion-proof, Solistrand, Budget, Plasti-Grip, knife disconnect, parallel and butt connectors. The back of the catalog contains samples of each type of AMP terminals.

MICROFILM STORAGE

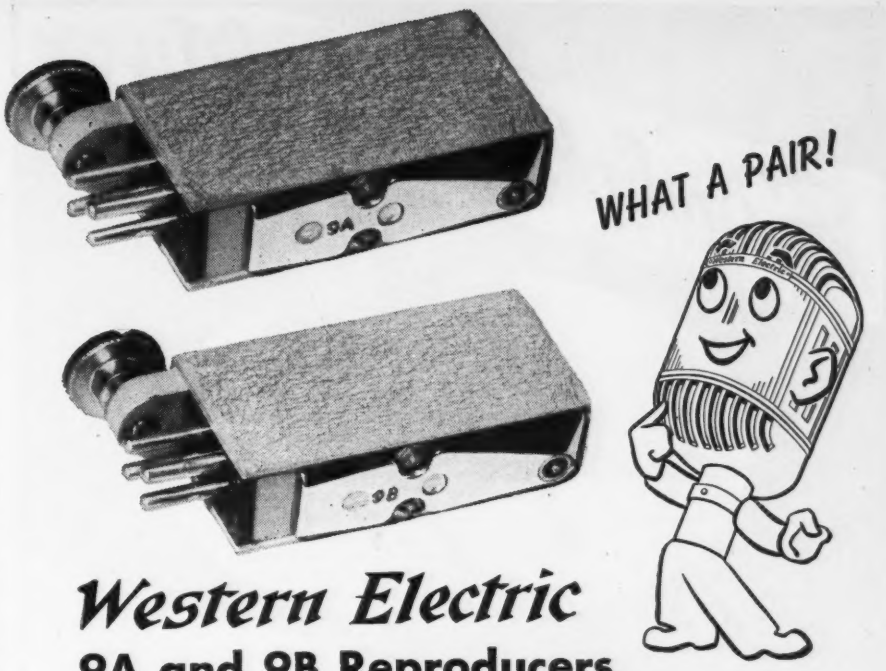
To aid business and industrial organizations to solve problems connected with storage of photographic films and prints, Eastman Kodak Co., Rochester 4, N. Y., has issued a 16-pg. pamphlet on "Storage of Microfilms, Sheet Films, and Prints." The pamphlet discusses the protection required, classification of records, storage and fire protection, relative humidity and temperature, and methods for testing film and papers for hypo elimination.

TELEVISION COMPONENTS

Diverse television components used in the magnetic deflection for the picture tube and generation of horizontal and vertical scanning voltages are described in a 4-pg. catalog 147, issued by The Telectron Co., 1988 East 59 St., Cleveland 3, Ohio. The folder gives data on a number of magnetic deflection yokes, yoke matching transformers, and shielded or open construction blocking oscillator transformers. Photographs, technical specifications and prices are included for each item.

INDUSTRIAL TUBE DATA

New and revised pages for the GE Industrial Tube Manual have been issued by the Electronics Dept., General Electric Co., Schenectady, N. Y. Supplement No. 3 (Nov. 1946) contains data sheets on two types of thyratrons, one phototube, and eight types of vacuum capacitors G1-1L21 to GL-1L38, (omitting 26-32). A quick selection chart, prices, and ordering instructions are also included in the supplement.



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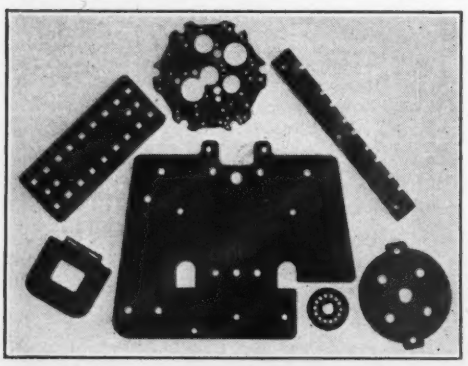

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BUYER'S REFERENCE GUIDE

As the production of radio equipment and components continues to rise, the catalogs of the supply houses are assuming their prewar proportions again. An excellent cross-section of the diverse paraphernalia, which make up industrial electronic and tele-communications equipment, is contained in the new 1947 reference book and buyers guide published by Walker-Jimieson Inc., 311 South Western Ave., Chicago 12, Ill. The design engineer, dealer and amateur will find sections on receiving and industrial electronic tubes, a representative section on diverse test equipment and meters, voltage controls and industrial process controls, public address equipment, communication receivers, and thousands of electronic parts and components for replacement and design applications. The 100-pg. catalog is profusely illustrated and includes prices.

ROTARY SOLENOIDS

Several new basic designs of Ledex rotary solenoids for aircraft and industrial applications are discussed in a 34-pg. Engineering Letter published by George H. Leland, Inc., 133 Webster St., Dayton 2, Ohio. Full information is given on the 1⅞ in. and 2½ in. diameter basic designs of solenoids. The bulletin also contains technical data on rectifiers recently developed for economical operation of the dc solenoids from an ac source. Due to the technical nature of the pamphlet it is of particular interest to engineers and designers. A large amount of technical specifications, price data, dimensional drawings and power graphs is included.

RELAY MANUAL

Coil resistance, voltage, contact data, sensitivity, insulation, dimensions, and prices are given for a wide variety of relays in the relay manual prepared by Wells Sales, Inc., 4717 W. Madison St., Chicago 44, Ill. Among the types included in a stock of more than one million relays are ac, dc, motor control, thermal, time delay, low and high frequency keying, standard and midget telephone relays, and a large number of aircraft types.

CRYSTAL DIODES, THYRATRONS

Data sheets providing electrical specifications, physical dimensions, and typical circuit applications of germanium and silicon crystal diodes, hydrogen thyratrons, and high intensity flash tubes are available from the Electronic Div., Sylvania Electric Products Inc., 500 Fifth Ave., New York 18. Characteristics curves of type 1N34 germanium crystal used as second detector in TV and FM discriminators are given, as well as operating data of silicon diodes used as converters up to 25,000 mc. A typical circuit of type 4C35 hydrogen thyratron is shown along with specifications.

TUBE SOCKET GUIDE

To help find the correct socket and tube cap connector for a particular type tube, E. F. Johnson Co., Waseca, Minn., have prepared a tube socket guide which identifies a suitable socket and connector for each of some 800 transmitting, control and regulator, rectifier, receiving, and miscellaneous tubes. Tubes are grouped according to their use and arranged numerically within each group.

SOLDERLESS CONNECTORS

The complete line of T&B Lock-Tite pressure connectors is presented in handy and compact form in a folder issued by Thomas & Betts Co., Elizabeth, N. J. Included in the booklet are descriptions and specifications of solderless lugs, tee-parallel taps, 2-way connectors, lugs and parallel connectors for solid or stranded wire.

PARTS CATALOG

Four hundred and thirty-six parts of an enlarged and improved line of multi-wire connectors, tip plugs and jacks, pilot dial and panel lights are described in the condensed general products catalog No. 969 available from E. F. Johnson Co., Waseca, Minn. The catalog also contains detailed data on variable transmitting capacitors, inductors, tube sockets, "Q" antennas, insulators, couplings, rf chokes, and tube cap connectors.

MAGNETIC IRON POWDERS

Hydrogen-reduced magnetic iron powders, available for frequencies ranging from 1,000 cycles to 200 mcs, are the subject of a 28-pg. data book, issued by George S. Mepham Corp., 2001 Lynch Ave., East St. Louis 3, Ill. The booklet contains complete data on ten grades of magnetic iron powders including photomicrographs, electrical and mechanical properties, graphs of "Q" vs. frequency, and initial permeability vs. density, etc.

TEST INSTRUMENTS

Whether it be an inexpensive pocket multitester or a precision instrument, it can probably be found in catalog No. 129 of Radio City Products Co., 127 W. 26 St., New York, which contains a comprehensive listing of test instruments including the Reiner line of precision equipment. Included are a wide variety of multitesters, tube testers, signal generators, vacuum tube voltmeters, square wave generators, and associated components.

RADIO COMPONENTS

Three types of permeability tuners, two for superheterodyne and one for regenerative receivers are described in parts catalog No. 21, available from Aermotive Equipment Corp., 1632-8 Central St., Kansas City 8, Mo. The 4-pg. folder also gives illustrations and technical data on a 5 in. slide rule dial, a phono-oscillator, chassis, and diverse hardware.

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The surging, booming post-war rush of radio broadcast construction finds Wincharger again supplying the industry with the bulk of its towers. And for the same reasons. Wincharger's guyed tower, with its uniform sections and resulting mass-production economy, continues to be the industry's recognized dollar-and-cents value. The convenience of Wincharger's "packaged-buying" and Wincharger's reliable maintenance and service, continue to be powerful attractions.
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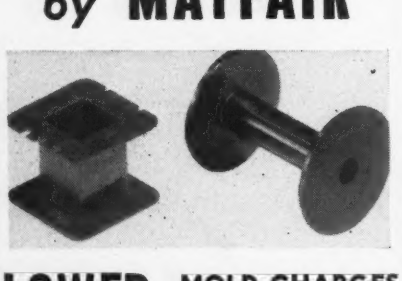

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"Q" INDICATOR

The characteristics, applications, and specifications of the Freed low frequency "Q" indicator type No. 1030 are contained in a 4-pg. folder issued by Freed Transformer Co., Inc., 72 Spring St., New York 12, N. Y. The instrument, which measures directly the "Q" factor of coils, consists of an RC low frequency oscillator, a variable impedance amplifier, a variable precision capacitor, and a vacuum tube voltmeter of special design. The range of "Q" factors is from 0.5 to 500 over a frequency range from 50 to 50,000 cycles.

SOUND PROJECTORS

Descriptions of high intensity reflex trumpets, driver units, exponential sound projectors, weatherproof horns, and speaker baffles for public address systems compose the contents of an 8-pg. catalog published by Kainer & Co., 761-771 West Lexington St., Chicago 7, Ill. A general description of each unit is supplemented by illustrations, complete technical data, and prices. The back of the booklet is devoted to floor and desk microphone stands.

FILTERS AND CAPACITORS

Suitable for all general replacement applications a wide variety of P-B paper and electrolytic capacitors are described in a 4-pg. bulletin issued by Atlas Condenser Products Co., 548 Westchester Ave., New York 55, N. Y. Paper capacitors range in value from .005 to .25 mfd to 600 volts working voltage. Single and dual-section tubular electrolytics are available for all standard capacities. Also described are radio noise filters and fluorescent filters.

VITREOUS ENAMEL RESISTORS

Fixed and adjustable power resistors of the vitreous enamel type for industrial electrical and electronic applications are described in an engineering data folder distributed by P. R. Mallory & Co., Inc., Indianapolis, Ind. The line includes fixed tab, adjustable and ferrule construction in commercial types and type RN fixed resistors. Detailed specifications are given for each type, including ratings and dimensions, construction and performance data.

GRAPHIC RECORDERS

The latest issue of the technical bulletin, "Sound Advances", published by Sound Apparatus Co., Millington, N. J., deals with the new twin graphic recorder and regulated power supply manufactured by the company. The twin recorder is an instrument for making two simultaneous records of independent variables, such as noise and vibration, loudness and sound intensity, dc voltage and ac ripple, etc. Also described is model DS power supply, designed for exacting laboratory use.

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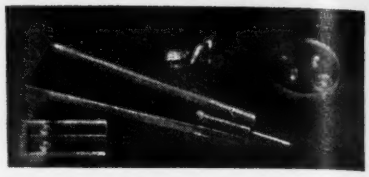

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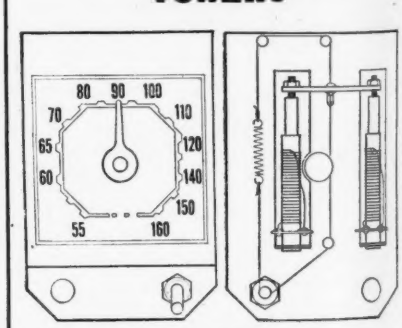

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PORTABLE MEGAPHONE

The type TPM-2 power voice portable electric megaphone, which is capable of projecting sound over a range of more than ½ mile, is described in a specifications sheet issued by Taybern Equipment Co., 120 Greenwich St., New York 6. Front page of the bulletin gives an illustration of the unit consisting of a projector and amplifier and lists many possible uses. The back contains a general description including dimensional and electrical data.

SHIP-TO-SHORE RADIOTELEPHONE

For two-way communication for commercial and private vessels the 75-watt radiotelephone Model ET-8012-D has ten crystal controlled channels, a ten-tube transmitter and a 9-tube receiver. A folder on this equipment, issued by Radiomarine Corp. of America, 75 Varick St., New York 13, includes technical and mechanical specifications, dimensions and weights, power supply requirements, illustrations and typical installations.

VARIABLE RESISTORS

Complete information on a comprehensive line of carbon and wire-wound variable resistors is contained in a 12-pg. engineering data folder published by P. R. Mallory & Co., 3029 E. Washington St., Indianapolis, Ind. Included are engineering data, electrical and mechanical characteristics, taper charts and dimensional drawings for diverse types of variable resistors, and T and L pad attenuators. A specification sheet printed on tracing paper permits establishing various specifications on controls.

DIE-LESS DUPLICATING

A large amount of new material illustrating many "Die-less Duplicating" applications in various industries is contained in the latest Di-Acro catalog, No. 46-11, issued by O'Neil-Irwin Mfg. Co., Lake City, Minn. The booklet describes many recent improvements in the precision machines, which have increased their working range. It also shows a redesigned line of brakes, which are available in 6, 12, 18, and 24 in. sizes. All models have a material capacity of 16 gage cold rolled sheet steel. A number of photographs illustrate the operation and applications of diverse duplicating machines.

BLIND RIVETS

Cherry blind rivets for every job are described in catalog E-46, distributed by Cherry Rivet Co., 231 Winston St., Los Angeles 13, Cal. The introductory pages give basic explanations of methods of blind and pull riveting. A number of types are discussed such as self-plugging blind rivets, hollow rivets, and other types. A number of hand and pneumatic guns are shown. The back of the 24-pg. booklet describes associated tools and parts.

ELECTRONIC COMPONENTS

Specification sheets giving exact data on terminal lugs, terminal boards, slug-tuned coils, and swagers are contained in a 20-page tabbed-section catalog published by Cambridge Thermionic Corp., Dept. 5, 455 Concord Ave., Cambridge 38, Mass. Reprint of a loan agreement form for the loan of pressure swagers is also included. The catalog is replete with diagrams, dimensional sketches and illustrations.

AMATEUR RADIO EQUIPMENT

The 150 watt 32V-1 and the 500 watt Collins 30K amateur transmitters are described in two 4-pg. folders issued by Collins Radio Co., Cedar Rapids, Iowa. The 32V-1 transmitter covers six amateur bands and has a straightforward tube lineup, consisting of a 6SJ7 oscillator, 6AK6 rf buffer, 6AG7 harmonic amplifier, 4D32 rf power amplifier, two 807 modulators, doublers, af amplifiers, and rectifiers. The 30K uses the 310A exciter unit, and a line-up of 11 tubes to provide 350 watts on phone or 500 watts on CW.

SHIPBOARD RADAR EQUIPMENT

A new 12-page radar brochure issued by Dept. AP-10, Radiomarine Corp. of America describes in detail model CR-101 shipboard radar designed for commercial ships and large pleasure craft. The pamphlet includes illustrations of the equipment, samples of actual radar scope pictures taken under operating conditions, and dimensions of the equipment. In addition to ranges of 5, 15, and 50 miles, the radar apparatus permits resolution of objects located from 80 yards to 1.5 miles.

DESK-SET TELEPHONE

A unique method of analyzing and sectioning the construction of the new 1000 series desk Masterphone by means of a series of four transparent overlays has been incorporated in a 24-pg. color booklet published by Kellog Switchboard and Supply Co., 6650 South Cicero Ave., Chicago 38, Ill. By turning the pages and progressively disassembling the desk-set telephone interesting details may be studied, such as its ringer design, capacitor and induction coil, one-piece interconnecting block, and the base plate.

ELECTRIC CONTROL DEVICES

Ward Leonard Electric Co., Mount Vernon, N. Y., has issued bulletin No. 100,000 which contains descriptive information and illustrations on a diverse number of electric control devices. The 8-pg. catalog includes ac and dc motor starters, speed and voltage regulators, resistors, ring and plate rheostats, switches, magnetic contactors, relays and dimmers. Engineering specifications and dimensional information are given for each of these devices.

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CERAMIC INSULATING MATERIALS

The principles of ceramic insulating materials are explained in a 28-pg. catalog form 720, issued by Centralab, 900 E. Keefe Ave., Milwaukee 1, Wis., containing information on standards, design criteria, body characteristics, and a listing of certain established shapes and sizes in common use. Steatite, Cordierite, Zirconite and a wide range of dielectric materials are described. A comparative table of average characteristics and listing of ceramic tolerances is also given. Groupings include male and female bushings, strain insulators, coil forms metallized ceramics, and miscellaneous steatite pieces.

AMATEUR RADIO EQUIPMENT

The extensive paraphernalia of equipment and components comprising the amateur radio field are displayed in catalog No. 37, published by the Hallicrafters Co., 2611 S. Indiana Ave., Chicago, Ill. The 36-pg. booklet contains a number of new communications receivers and transmitters, amplifiers, tape recorders and reproducers, besides the standard equipment which is making its reappearance again. Of special interest are the SX-43 receiver, which covers 540 kc to 108 mc in six bands on AM, FM, and CW. The SX-46 is a low-priced AM & CW receiver with crystal filter and "S" meter. The HT-17 is a low-power CW transmitter, covering the amateur bands from 3.5-30 mcs. The HT-4E transmitter, heart of the SCR-299's, is also available again. In the vhf-uhf field the models EP-132, S-37, and S-36A have advanced design features. High-fidelity AM-FM receivers, amplifiers, and reproducers are also included. An FM-converter to adapt old receivers to the new band and new-design antennas are shown in the back of the catalog.

RADIO COMPONENTS FOR HAMS

First in a new series of "ham" flyers has been issued by Sun Radio & Electronics Co., parts distributors, 122 Duane St., New York.

MORE PERFECT COILS or SPRINGS

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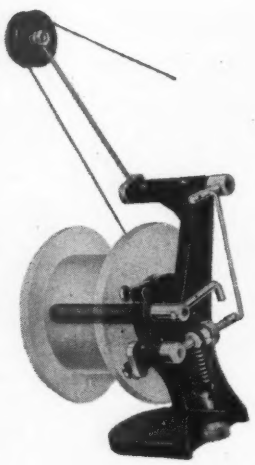

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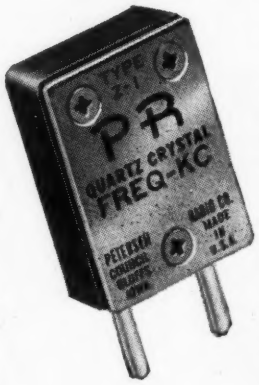

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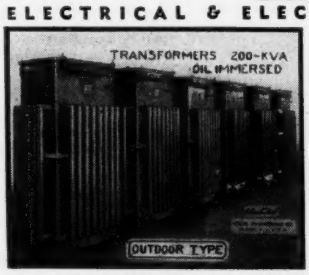

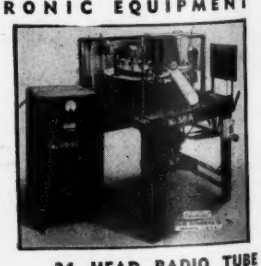

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TELE-TECH

Advertisers, April 1947

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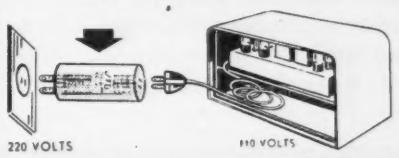

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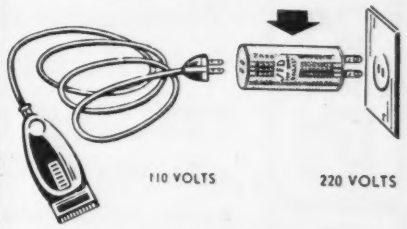
JFD manufactures special 220 to 110 volt stepdown cords for each type of table model radio including .2 amp, .3 amp, and .35 amp types. All cords available with any combination of male and female American, British or Continental plugs.



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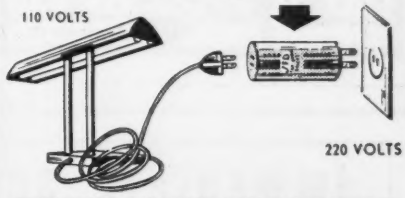

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Farnsworth Expands

Expansion of research, engineering, manufacturing and administrative facilities at the Fort Wayne headquarters plant of the Farnsworth Television & Radio Corp. includes occupation of a new two-story addition. This permits Farnsworth's entire research and engineering departments to be located at the Fort Wayne plant. The expansion program has doubled the space available here for manufacturing operations. Television studio and transmitting equipment, industrial telemetering equipment, automatic record changers, special tubes and other electronic apparatus as well as television receivers and mobile communications equipment are manufactured here.

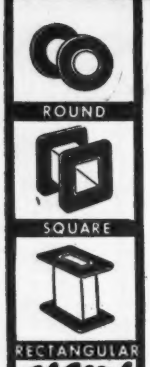
RWMA's Officers

The Resistance Welder Manufacturers Assn., at its annual meeting Jan. 17, elected as president George N. Sieger, president of S-M-S Corp., Detroit, Mich. T. S. Long, vice-president and general manager of Taylor - Winfield Corp., Warren, Ohio, was elected vice-president.

DYNAMIC MICROPHONES

Dynamic microphones for every purpose and application, ranging from amateur use to high fidelity broadcasting are described in the latest catalog released by St. Louis Microphone Co., 2726-28 Brentwood Blvd., St. Louis 17, Mo. Included are specifications and descriptions of amateur, standard broadcasts, outdoor, FM high fidelity and directional Cardioid microphones. Also available for special applications are plastic hand microphone, the Colormikes, a noise cancelling differential microphone.

SOME OF THE HAZARDS THAT AFFECT YOUR COIL BASES



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DY2L	40°	5 mh.	22 mh.	3 7/16"	15.75
DY4L	40°	1.5 mh.	45 mh.	3 7/16"	15.75

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OT-102V	Unshielded Vert. OSC (60 cycles)	2.50

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Cat. #	Use	Core	Price
YT-111H	Horiz.	"Hipersil"	$26.40
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YT-112V	Vert.	Iron	10.95

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Roller-Smith portable laboratory; 5" scale bakelite case with handle; 5½" w. 6" h. 3½" d. New $19.50

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.35 MF, 5000 V DC $2.95

Oil Filter Condensers

10 Mfd. 600 VDC	$1.50
4 Mfd. 1500 VDC	2.75
4 Mfd. 3000 VDC	6.50

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